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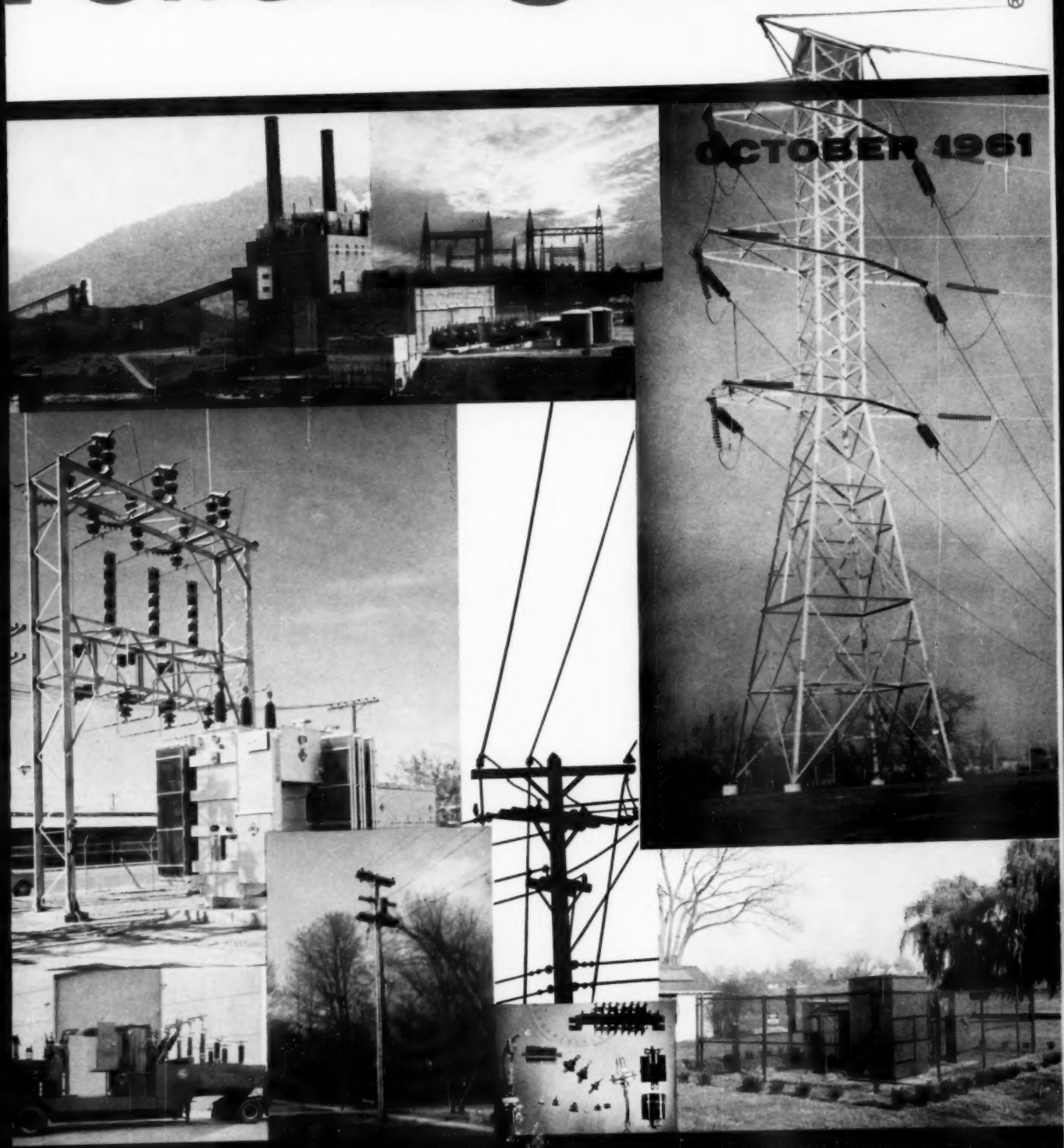

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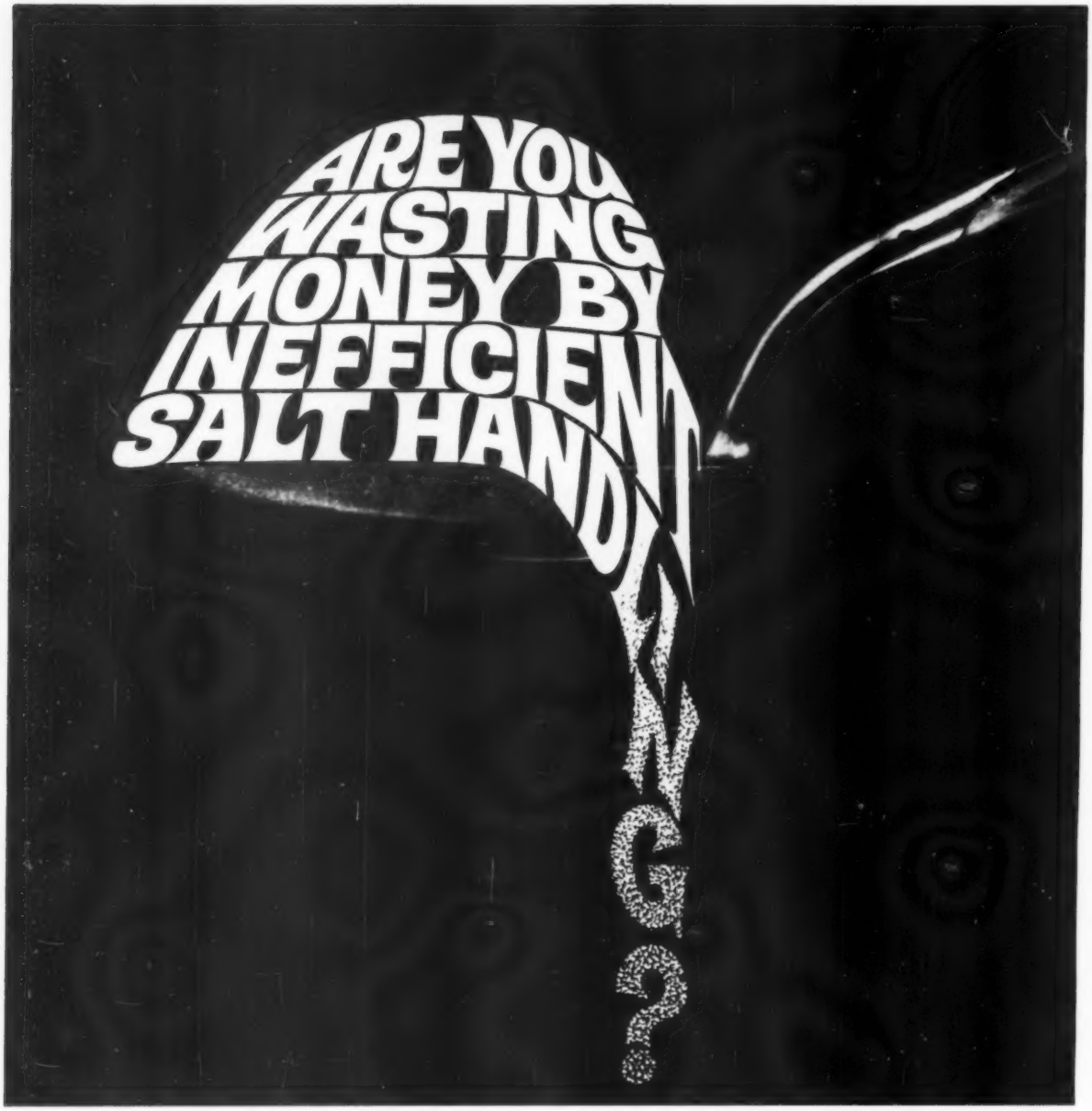

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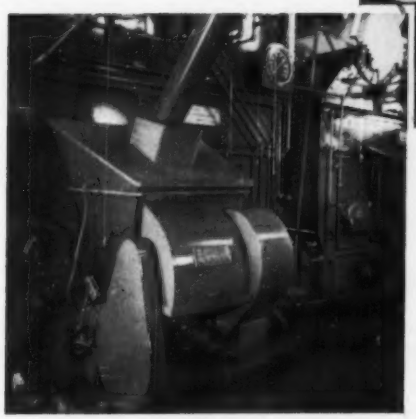

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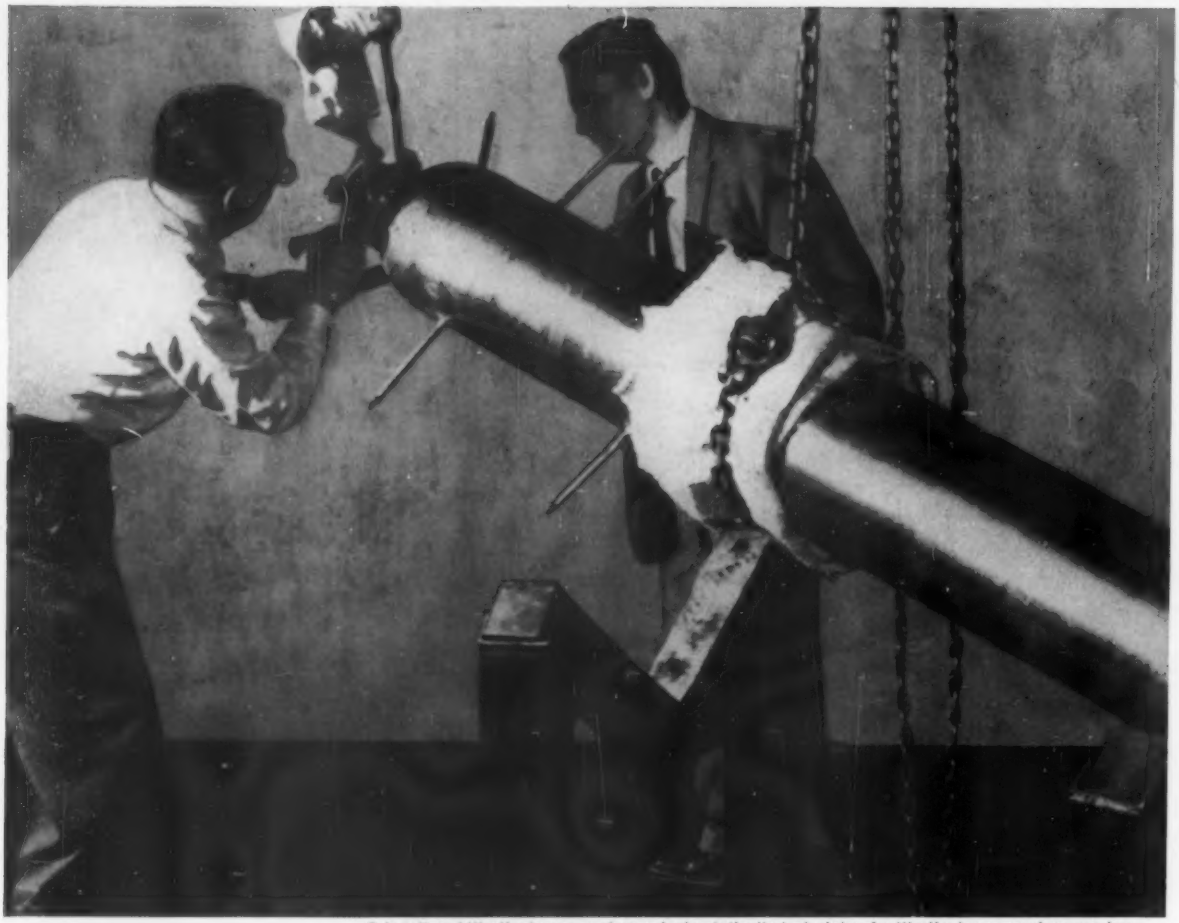

Grinnell and Westinghouse engineers hydrostatically test piping for Westinghouse nuclear reactors

Grinnell prefabricated pressure vessels maintain environmental conditions in Westinghouse test loops

This torpedo-shaped vessel, which is made of centrifugally cast stainless steel pipe, will play a vital role during nuclear research reactor experiments at Westinghouse. Its job — maintaining the desired pressure in a high temperature, high pressure in-pile test loop.

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Grinnell shop-fabrication assures conformance to tolerances several times more critical than normally necessary.

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Comment

This issue of Power Engineering is devoted exclusively to Electric Transmission and Distribution, to bring our readers the latest developments in this field. All articles are written by recognized authorities, and contain valuable information.

The recent announcement, by Edison Electric Institute, that investor-owned utilities will spend $7.3 billion for new transmission lines is dramatic proof of the timeliness of this special edition.

Bob McCaw

EDITOR

Power Engineering®

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ON THE COVER

This montage of photos depicts the many elements of Electric Transmission and Distribution. Starting at the large utility generating station, power is stepped up in a substation. From there it is sent over transmission lines to load centers, where it is stepped down to distribution voltages. Final step is another reduction to consumer utilization voltage

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around the power circuit

Generator of this prototype solar thermoelectric power plant is "box" at center containing 72 elements each composed of p-type and n-type semiconductor materials

INVESTOR-OWNED electric utility companies plan to spend approximately $8 billion for new electric power transmission facilities through 1970, reports Philip A. Fleger, president of Edison Electric Institute and of Duquesne Light Co. "By 1970 we expect all the major power systems to be capable of operating on an interconnected basis throughout the United States," Fleger states.

In 1970, total transmission investment of the investor-owned companies will be about $14 billion—more than twice the present total of $6.7 billion. Many of the transmission lines now planned will operate at 345,000 volts. Some will be constructed so that they can be converted at a future date to 500,000-v operation, and extensive research in even higher transmission voltages is being carried on.

Fleger states that electric companies have been spending a total of about $3.2 billion a year for new plant and equipment, the equivalent of 10 per cent of new construction for all American business. He points out that with only about 1/16th of the world's population, our country now has about one-third of the world's power-producing capacity, and about five times the miles of transmission lines in the U.S.S.R.

Russia's latest revised goals for power production aim at a per capita production of about 3000 kwh in 1970. Our production is expected to be around 7500 kwh per capita that year.

SMALL, SUN-POWERED thermoelectric power plant and pumping unit, capable of sustaining individual families or villages in underdeveloped areas by irrigating the land they live on and supplying their household water needs, is under development at Westinghouse, in cooperation with the Solar Energy Laboratory of the University of Wisconsin.

The power generated drives an electric motor having a water pump connected directly to it. These are the only moving parts in the whole irrigation system.

The 50-watt prototype system uses an 8-ft parabolic mirror which gathers the sunlight and focuses it on a thermoelectric generator. The generator is a metal "box" about 8 in. on a side, about 2 in. thick, and weighing just over 16 lb. It can operate with temperatures on its hot side as high as 1100 F. However, in order to extend generator lifetime and reduce the initial cost of the system, especially the mirror, an operating temperature of 840 F has been adopted. Cool side of the generator runs at 150 F.

NEARLY 16 MILLION pounds of aluminum electrical cable will be used in Arizona Public Service Co.'s new 345,000-v transmission line to extend 300 miles from the Four Corners power plant in northwestern New Mexico to Phoenix. The total amount is to be supplied by Kaiser Aluminum & Chemical Sales.

A 125,000-KW electric generating unit to cost about $20 million will be the next capacity addition to the power system of Wisconsin Public Service Corp. The new unit will be installed at the Pulliam Plant in Green Bay, and will increase Public Service's total generating capacity to 615,500 kw.

BLAW-KNOX has been awarded a $4-million contract to design and construct a new 100-million pounds per year polyvinyl chloride plant for Cary Chemicals, Inc. The new plant will be located on a 66-acre site directly on the Delaware River just west of Burlington, New Jersey.

NINETEEN engineering societies have moved into the new 20-story, $12,000,000 United Engineering Center on United Nations Plaza at 345 E. 47th St., New York 17, N.Y. Owned and operated by United Engineering Trustees, Inc., the Center becomes the largest concentration of professional engineering societies.

ELEVEN investor-owned electric utility companies of the Southwest Power Pool have offered to exchange 1,500,000 kw of seasonal off-peak electric power with TVA. J. Robert Welsh, chairman of the executive committee of the pool, explained that the plan is possible because the pool member companies have their highest usage of electricity during the summer months,

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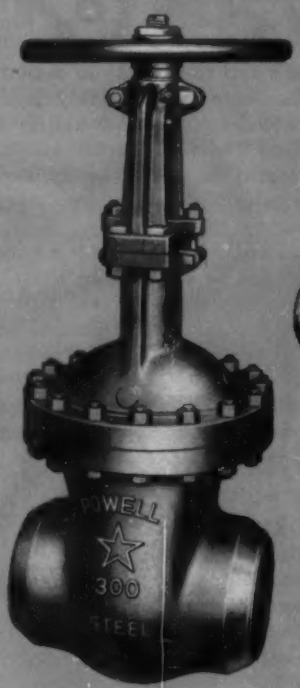
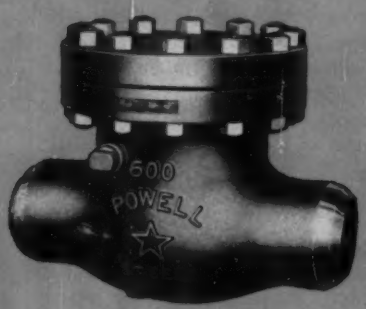
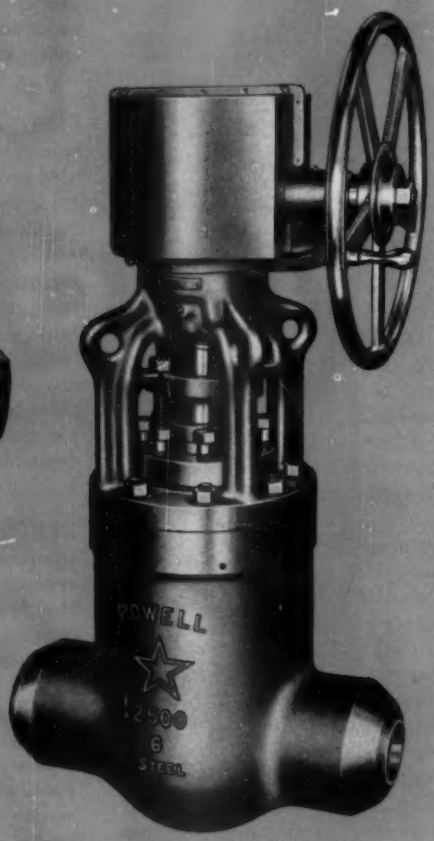


300-pound Steel Gate Valve — Fig. 3003 WE. Bolted flanged yoke-bonnet. Outside screw rising stem. Interchangeable solid or split wedges, renewable seats. Sizes, 1" through 30".



600-pound Steel Horizontal Swing Check Valve—Fig. 6061 WE. Bolted cap, renewable seat and disc. Has full flow area when valve is fully open.



2500-pound Steel Pressure Seal Gate Valve—Fig. 125003 WE. Enclosed bevel gears facilitate operation. Valves can also be supplied with spur gearing or motor operators for remote control.

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while TVA has its highest usage during the winter months.

The interchange of electricity between the two systems would effect economies, according to Welsh, because it would make it unnecessary for either participant in the agreement to build electric generating facilities costing many millions of dollars to meet the power needs covered by the exchange agreement.

around the power circuit

SAN DIEGO Gas & Electric Co. is joining with Southern California Edison Co. to build an automated, nuclear-fueled, steam-electric generating station to be located on a site approximately midway between the Los Angeles and San Diego load centers.

The plant will consist of a Westinghouse closed-cycle water reactor with auxiliary equipment necessary to supply steam to a 375,000-kw (electrical) Westinghouse turbine-generator. A conventional switchyard and transformers will permit transmission of the energy to load centers at 220,000 volts.

Westinghouse, jointly with Bechtel Corp., will design and construct the power plant on a ready-to-run basis. Site preparation and development will be undertaken by Southern California Edison at a cost of approximately $9.6 million. The power plant contract cost of $68,557,000 will bring the total cost for the first unit to approximately $78 million.

It is expected that the unit cost of energy over the life of the nuclear plant will be competitive with that produced by a conventional steam-electric plant burning fuel oil or natural gas. Plans call for additional units as required by load growth, with ultimate capacity of the plant reaching some 1.5 million kilowatts.

Target date for initial operation of the plant is July 1, 1965.

WORLD BANK, with the participation of private investors, has made a loan equivalent to $23.5 million to the Territory of Trinidad and Tobago for electric power development. The loan will help to finance the construction of a 100,000-kw thermal power plant at the capital, Port-of-Spain, the construction of a 41-mile natural gas pipeline to supply fuel for the plant, and the expansion of transmission and distribution facilities.

FIRST of two 11,300-kw gas turbine-generator power plants is scheduled to go into service November 15 at the Tracy substation of Sierra Pacific Power Co. 17 miles northeast of Reno, Nev. Westinghouse will supply the twin units, both self-contained and controlled automatically on a "turnkey" basis, which includes installation. Unattended, the plants will be operated from remote locations when needed to supply electricity to meet peak seasonal demands.

ELECTRICAL GENERATING equipment ordered by U.S. power systems from domestic sources for the first half of 1961 showed a capacity increase of 28 per cent over the same period last year, according to the Electric Power Survey Committee of Edison Electric Institute.

A total of 8,798,627 kilowatts of capacity was ordered by the end of June, compared with 6,874,045 kilowatts ordered during the same period in 1960. This brings the total of additions to generating capacity scheduled and on order for the years starting with 1961 up to 47,994,367 kilowatts of which 36,690,850 kw are in thermal units.

TWO SINGLE-STAGE reversible pump turbines to be supplied by English Electric to the North of Scotland Hydro-Electric Board will operate at 1200 feet, reportedly the highest head ever for such machines.

To be installed at the Board's new 400-Mw pumped-storage power plant at Cruachan in Argyllshire, the 142,000/136,500-hp units will pump water at night from an underground plant at Loch Awe to a reservoir 1200 feet above in readiness for daytime peak load requirements. The pump turbines were jointly developed by English Electric and Sulzer Brothers of Switzerland to meet the Board's specifications.

START has been made on major construction for an $8-million experimental nuclear superheat reactor, part of a research program sponsored by New York State electric utility companies.

The nuclear superheat reactor is being built at General Electric's Vallecitos Atomic Laboratory. It will be a fuel test facility to demonstrate the technical feasibility and improved economics of nuclear superheat. The new reactor will have a capacity of 12,500 kw of heat and is scheduled to go into operation late in 1962.

ESADA, a non-profit corporation formed by seven major electric utilities operating in New York State, has contracted with General Electric to design, construct and operate the reactor and is putting up $5,750,000 toward the cost of the superheat program. AEC has issued a construction permit.

GRISCOM-RUSSELL has purchased the exclusive rights to manufacture and sell deaerating heaters using designs and patents of Elliott Co., of Jeannette, Pa., a division of Carrier Corporation.

AEC has selected Allis-Chalmers to conduct a specialized nuclear study of the reactor for the first full-scale nuclear power plant to be built in Canada. The project will involve a digital computer study to determine power generating characteristics of the reactor core.

Called CANDU, the reactor will be heavy water moderated and cooled, a type which Canada has pioneered. It will be installed in the Douglas Point Nuclear Power Station, to be built near Kincardine, Ontario, on the shore of Lake Huron about 180 miles northeast of Detroit. Site preparation is now under way.

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who

William G. Long has been named manager of I-T-E Circuit Breaker Co.'s transformer and rectifier division. Long succeeds **Otto Jensen**, who recently joined the company's corporate engineering staff.

Philip A. Sprague, president of The Hays Corp., Michigan City, Ind., is the new president of the Instrument Society of America. **Nathan Cohn**, vice-president of Leeds & Northrup Co., Philadelphia, was named president-elect-secretary of the Society.

One of Sprague's first acts was to confer the first Philip T. Sprague Award on **William R. Summers** of Ebasco Services, and posthumously on **John R. Horton**, late of the Louisiana Power & Light Co. The $500 award will be given annually by ISA for "outstanding achievement in the conception, design or implementation of power plant instrumentation."

POWER ENGINEERING readers will remember Bill Summers as the author of one of the articles in the special issue on automation and the power field, published in January 1960.

Moloney Electric Co. has appointed **William H. Schiek** as manager of sales for the switchgear division. Schiek has been associated with the metal-clad switchgear field since 1936.

Alfred N. Major has become chief engineer of the Whitlock Manufacturing Co. Major joined Whitlock in 1950, and has been manager of the thermal design dept. since 1954.

Christopher T. Kastner has been named president of Transitel International Corp., a new affiliate formed between Baldwin-Lima-Hamilton Corp. and Industrial Process Engineers. The new company will be located in Paramus, N.J., will develop and make telemetering equipment and systems for industrial applications.

John M. McGurn is taking over as operating manager of Virginia Electric and Power Co. He will replace **Walter J. Matthews**, who has resigned to become executive vice-president of the Public Service Co. of Indiana. McGurn has been serving Vepco as Norfolk manager.

T. D. Lyons, comptroller of Allis-Chalmers, has been elected vice-president, administration, Industries Group. **W. S. Pierson** succeeds Lyons.

what

Atomics, which has been published as a section in POWER ENGINEERING since 1945, is now being issued by Technical Publishing Co. as a separate magazine, issued quarterly in July, October, January, and April. The new **Atomics** quarterly will continue to publish technical information on all aspects of nuclear energy development on the same technical level as before, but its scope will be expanded to cover the entire field more effectively. Although the development of atomic power will, naturally, constitute a major portion of the editorial content, detailed attention will also be given to other aspects of nuclear science, particularly to the use of isotopes in industry and to the growing use of radiation in the chemical industry.

During the summer, Andrew W. Kramer, editor of **Atomics**, visited nuclear energy establishments and laboratories in most of the central European countries, and the October issue of **Atomics** will feature his report on nuclear energy development in Europe.

Energy Review, a brand new publication service to the power field from Technical Publishing Co., appeared in July. ER is a pocket-size, illustrated, time-saving periodical. Issued monthly, it summarizes important articles from a large group of engineering magazines dealing with power problems, and presents these summaries as a guide for the busy engineer in his current reading. Editor of **Energy Review** is Chester R. Earle, long known for his reporting of power field developments as editor in various capacities for POWER ENGINEERING. For a sample copy of **Energy Review**, write to Technical Publishing Co., 308 E. James St., Barrington, Ill.

when

AIEE Fall General Meeting is scheduled for Oct. 15-20, at the Statler-Hilton Hotel, Detroit.

Fall meeting of the National Society of Professional Engineers will be held at the Hotel Roanoke in Roanoke, Virginia, October 19-21.

Fluid Controls Institute's fall meeting will be held at the Hotel Hershey, Hershey, Penna., on October 29th, 30th and 31st. The Institute's executive secretary is E. R. Rath, P. O. Box 667, Pompano Beach, Florida.

National Assn. of Corrosion Engineers, Northeast region, New York City, Oct. 30-Nov. 2; Southeast region, Nov. 27-Dec. 1, Miami, Florida.

Consulting Engineers Council, semi-annual meeting, Nov. 1-3, Miami Beach, Golden Gate Hotel.

1961 nuclear conference and atom fair, sponsored by American Nuclear Society and Atomic Industrial Forum, will be held in Chicago, Nov. 6-9. Conrad Hilton Hotel.

35th annual meeting of the National Electrical Manufacturers Association will be held Nov. 16 at the Plaza Hotel in New York City.

AIEE's Winter General meeting and Electrical Engineering Exposition, will be held Jan. 29-Feb. 2, 1962 in New York City.

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Consultants for this contract are Stichting Nederlands Adviesbureau Voor Ingenieurswerken in Het Buitenland, The Hague, in association with Tebodin, Advies-en-Constructionbureau NV., The Hague.

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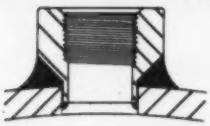

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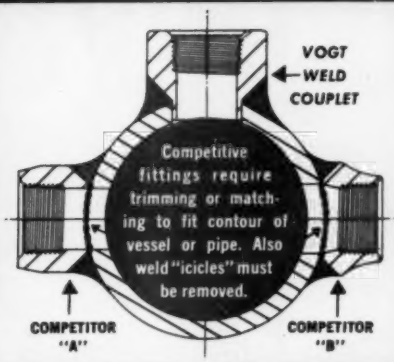
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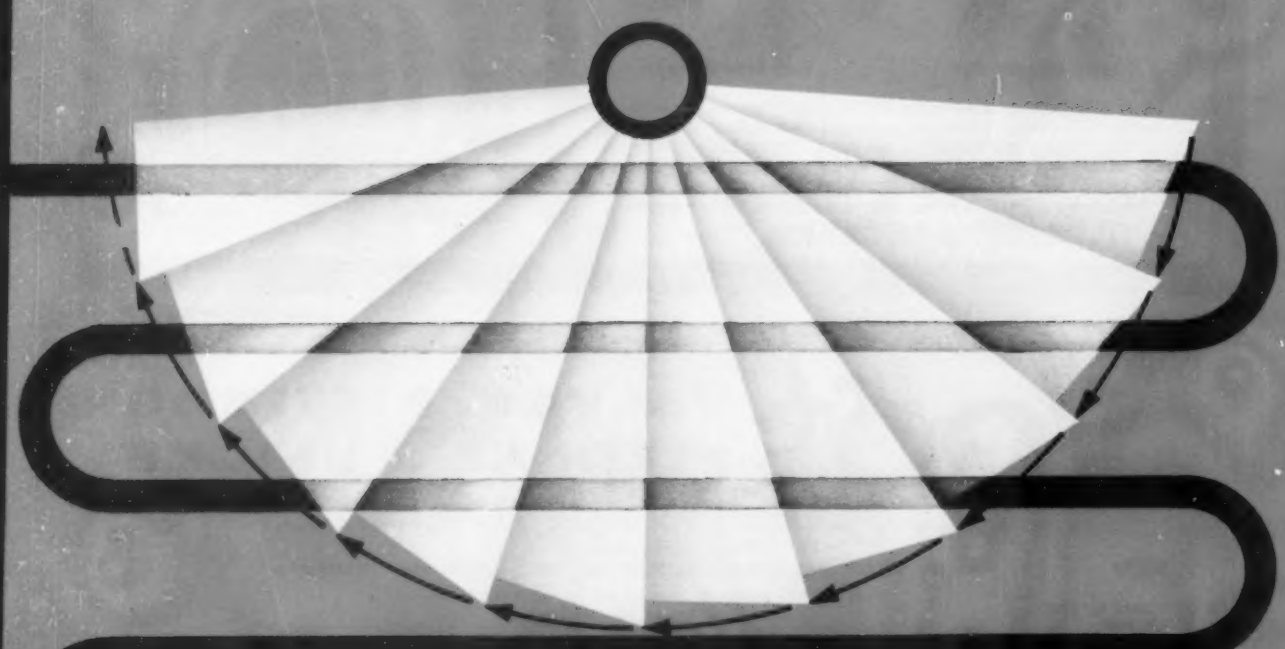
Diamond developed for more economical power...

AIR PUFF BLOWING=CLEANER BOILERS... AN APPRECIATIVE PUBLIC

THIS.....



Shaded area indicates sustained effective cleaning pattern.

Two of today's more critical conditions for efficient steam generation . . . clean boilers and acceptable stack emission . . . are assured with Diamond Air-Puff Soot Blowing Systems.

Increased cleaning efficiency is obtained because high density air is used as the cleaning medium and emitted in sustained high pressure puffs that are independent of receiver capacity or compressor size. Also, because no air is emitted at ineffective low pressures, there's greater economy in *use* of cleaning medium.

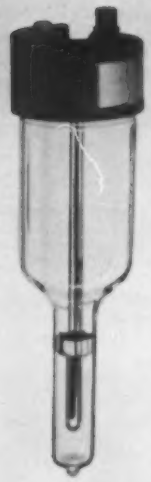
Acceptable stack emission is achieved because intermittent air puff blowing eliminates more concentrated and objectionable emission caused by continuous blowing arcs or blowing puffs of longer duration. In the standard Diamond Air-Puff System, intervals between air puffs are determined by the time required for build-up to optimum blowing pressure; however, if more positive control of stack emission is desired, intervals can be regulated by a simple valve adjustment.

The Diamond Air-Puff Blowing System for new *or* existing boilers of any type and capacity is further evidence of why "Diamond developed" means more economical power. Our engineers will be happy to discuss its application to your units. Call, write or wire for complete information . . . and thank you for reading our advertisement.

DIAMOND POWER

This is the new trademark of Diamond Power . . . a symbol of quality, integrity and progress . . . in products, systems and service.

DIAMOND POWER SPECIALTY CORPORATION, Lancaster, Ohio
DIAMOND SPECIALTY LIMITED, Windsor, Ontario



...with new rugged 7" reference and 3¼" glass electrodes...

new industrial pH system stresses reliability, flexibility

Beckman, world leader in pH instrumentation, introduces the all-new Model J pH System: compact transistorized analyzer, short, rugged electrodes, and accessory mounting assemblies. Here's continuous analysis equipment which provides reliability, flexibility, and convenience never before possible in industrial applications.

Check these Model J features, then see your Beckman Sales Engineer or Recorder Company Salesman for complete details, or write for Data File 78-10-06.

READOUT FLEXIBILITY. Available with both ma and mv output for use with any potentiometric or current recorders and controllers—or, with mv output only—recorder scale may be expanded to any 2 pH span full-scale. High or low alarm feature may be added.

SOLID-STATE ELECTRONICS. Assures reliability and saves long-term maintenance costs.

QUICK-DISCONNECT ELECTRODES. Short, rugged glass and reference electrodes feature capscrew for quick connect-disconnect of spade lug connectors. Speeds installation and replacement of electrodes.

DRIFT-FREE OPERATION. AC chopper amplification provides stability of 0.01 pH/24 hrs. over a −20°F to +122°F ambient temperature range.

HIGH ACCURACY AND SENSITIVITY. Output accuracy and meter sensitivity is ±0.02pH for full 0-14 pH or 0-±1400 mv range.

SIMPLIFIED MAINTENANCE. Plug-in components and circuits, rail-mounted analyzer chassis assure ease of maintenance, reduce downtime.

MINIMUM PANEL SPACE. Compact analyzer complements miniature current recorders, mounts in 6"x6" cutout.

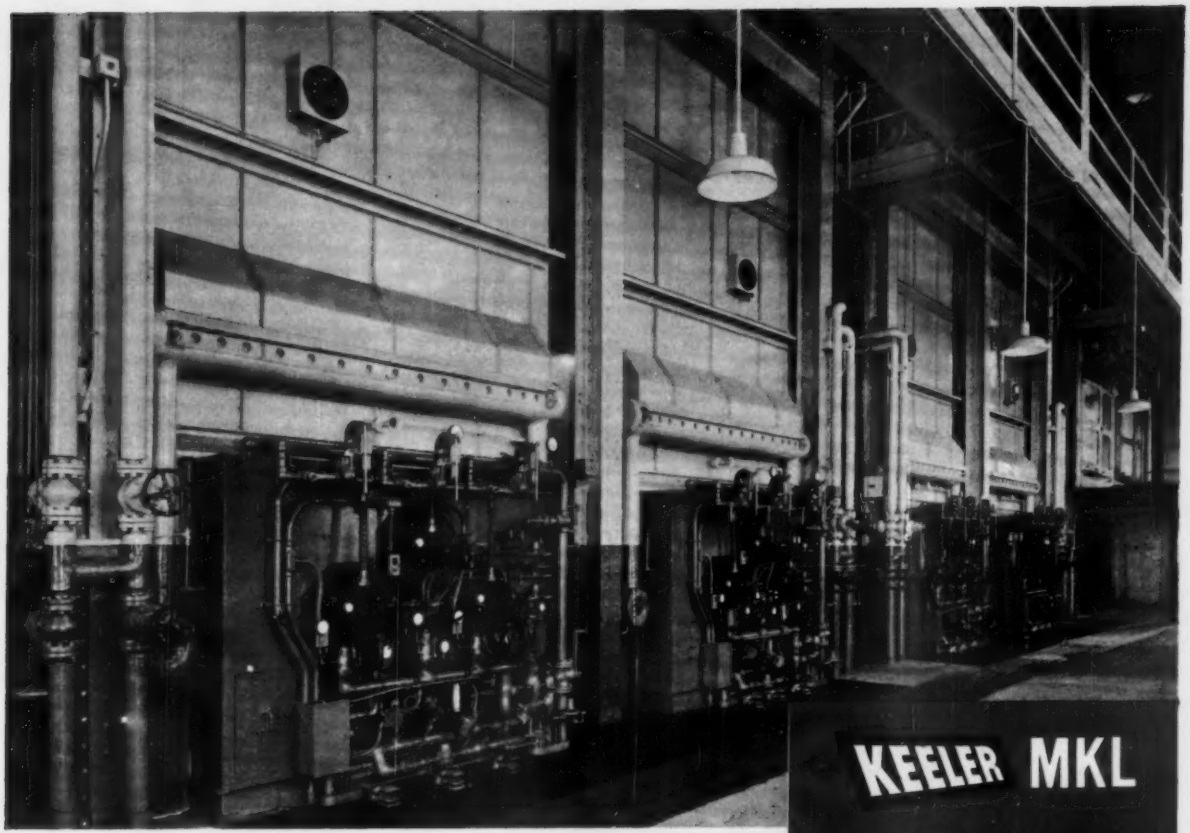
ACCESSORIES FOR YOUR REQUIREMENTS. Variety of flow chambers and immersion and submersion units adapt Model J System to your present and future plant applications.

Beckman INSTRUMENTS, INC.

SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION

Fullerton, Calif.

For more data circle 510 on Post Card



Consulting Engineers: H. M. WILSON CO., INC., Philadelphia 30, Penna.

FOUR KEELER TYPE MKL STEAM GENERATORS EXCEED EFFICIENCY GUARANTEE AT SEARS

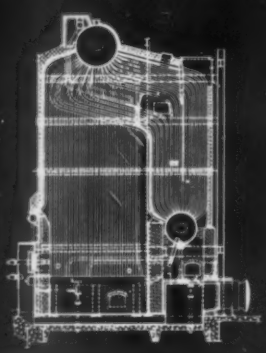
The Sears, Roebuck and Co. mail order plant in Philadelphia encompasses millions of square feet of usable space. The entire steam requirement plus adequate standby is supplied by four quick-response Keeler Type MKL Steam Generators installed in a recent modernization.

Test results have exceeded the guarantee of efficiency and their operation has been *"most satisfactory"!* The new MKL's are 40,000 lb stm/hr combination oil-gas, custom-designed units, 175 psi operating pressure. They were installed in the space previously occupied by four of the six 500-hp boilers which they replaced.

The space and versatility advantages experienced at Sears are typical of Keeler MKL's. The basic design provides true economy and efficiency with quick response to load changes. MKL's are cross drum, bottom supported type available in capacities up to 70,000 lb stm/hr. They're easy to maintain, flexible to space requirements, efficient and durable.

There's a dependable Keeler Water Tube Steam Generator for every requirement . . . from low cost package units to 100,000 lb/hr and field erected units up to 200,000 lb/hr—for all fuels, all types of firing. *Write or phone for complete information . . .*

KEELER MKL



WRITE FOR FREE BULLETINS . . .
No. MKL-1: Type MKL Boilers
No. MK-1: Type MK Boilers
No. DK-2: Type DK Package Boilers
No. F-14: Type CP Boilers
No. M-2A: Type CPM Package Boilers

SEARS
ROEBUCK AND CO.
Mail Order Plant
Philadelphia

The plant serves catalog customers in 8 states and the District of Columbia. Also located here are Sears' eastern territory headquarters offices, a department store, rail and motor freight terminals and warehouses.

KEELER WATER TUBE Boilers

The Seal of Quality in Water Tube Steam Generators

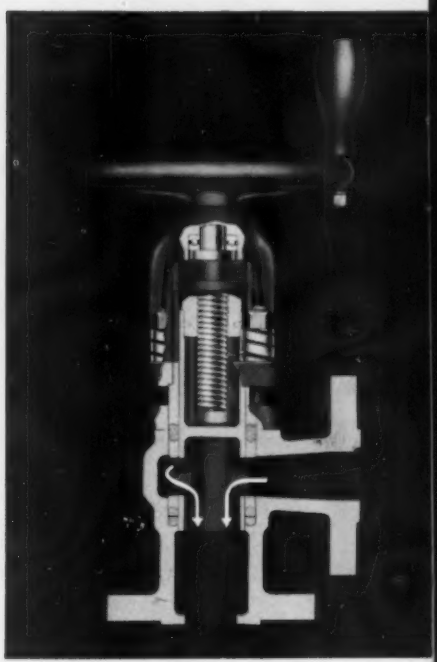
— ESTABLISHED 1864 —

E. KEELER COMPANY
100-200 West Street
Williamsport, Penna.

— *OFFICES IN PRINCIPAL CITIES* —
In Canada: Canadian Vickers, Ltd., Montreal

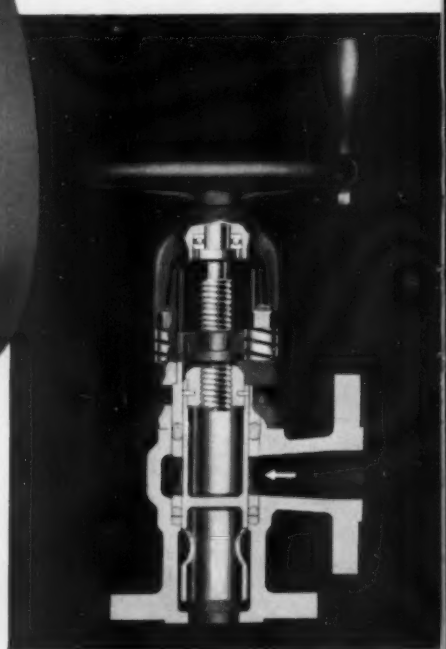
why over

Flanged connection, Yarway Seatless Blow-Off Valve, angle design.



▲ *Yarway Seatless Blow-Off Valve in open position. Note full, free discharge.*

▼ *Valve in closed position. Note tight shut-off.*



16,000 engineers choose and use YARWAY SEATLESS boiler blow-off valves

■ SAVING IN MAINTENANCE COSTS
■ FREEDOM FROM BOILER OUTAGES

These are the reasons—proved again and again by engineers who know *performance*, in thousands of installations over the last 50 years. Yes, these are the reasons why *Yarway Seatless* has become virtually the "standard" on all low to medium pressure boilers today!

Check these features that are responsible for the acceptance of these time-honored but truly modern, compact valves:

■ **UNIQUE SEATLESS DESIGN** — full, free discharge . . . combined with drop-tight shutoff . . . and no seat to score, wear, clog or leak.

■ **BALANCED HOLLOW SLIDING PLUNGER** —made of nitralloy with a "glass hard" surface that resists erosion, high temperatures and sudden shocks. "Polishing" action lengthens life of packing rings.

■ **COMPRESSION YOKE SPRINGS** — heavy coil springs under yoke nuts maintain continuous pressure on reinforced packing above and below valve port to keep valve tight.

■ **BALL BEARING HANDWHEEL**—for smooth operation, easy opening and closing.

■ **NON-RISING STEM.** Valve cannot be opened or closed too quickly. Water hammer is prevented.

■ **STREAMLINED BODY AND YOKE.** Strength where strength is needed—without unnecessary bulk. "Compact" over-all design.

■ **CHOICE OF FIVE SIZES—1″ to 2½″,** angle or straightway designs, flanged or screwed ends, available in any tandem combination.

If you are planning purchase of a new boiler, or modernization of present boilers in pressure ranges up to 415 psi, *insist* on protecting your investment with new Yarway Seatless Blow-Off Valves.

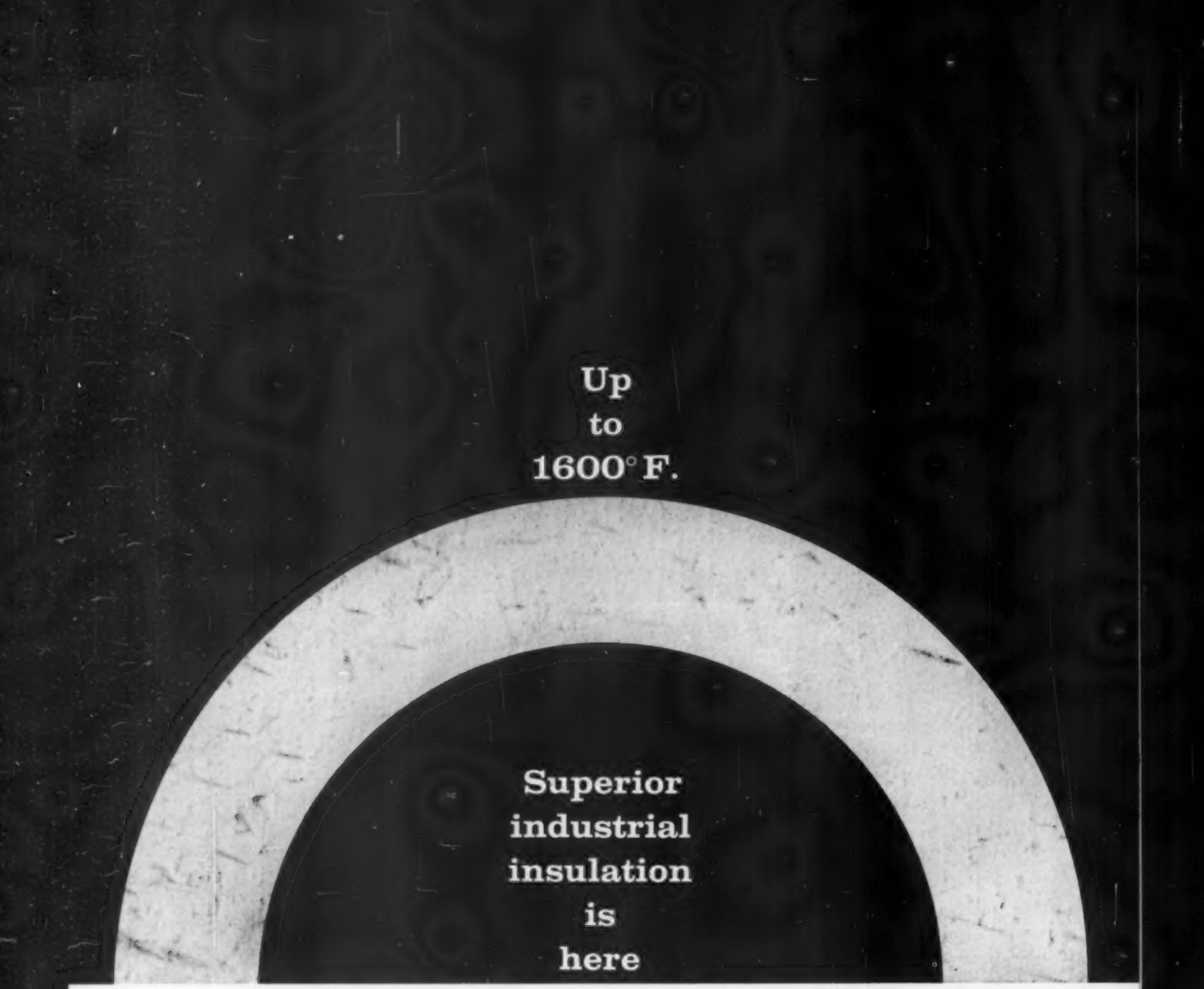
They'll give you maximum dependability, minimum maintenance, and satisfaction that is beyond price—all at a very *low* cost per year.

Write for Yarway Bulletin B-427.

YARNALL-WARING COMPANY
100 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING

For more data circle 512 on Post Card



This is Careytemp®

Composition — A new pipe and block insulation material . . . millions of glassed-in air cells of expanded silica bound together, reinforced with inorganic fibres. Gives exceptional strength, yet is lighter than other industrial insulations. Density: 9 lbs. per cu. ft.

High Moisture Resistance — Absorbs practically no moisture. Minimum efficiency loss under wet or humid conditions.

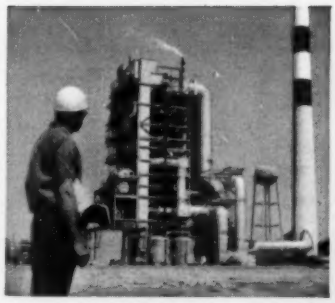
Low Shrinkage — Practically no linear shrinkage, even at high temperatures (0.7% at 1200° F.). Minimum heat loss at joints.

Low Thermal Conductivity — Only .33 B.T.U./sq. ft./hr./°F. at 100° F. — .77 at 1000° F. mean.

High Acid & Corrosion Resistance — Improved performance on acid-processing and stressed stainless steel equipment. Not damaged by most acids. Chemically-inert composition ideal where corrosion is a problem.

Wide Size Range — Available in larger labor-saving sizes. Blocks in new 24" widths and pipe insulation in half sections through 24" pipe size.

Over four years of field use have proved Careytemp, following thorough laboratory testing at Mellon Institute of Industrial Research. For Careytemp samples and additional specifications, write Dept.PW-1061.Insulation Division, The Philip Carey Mfg. Company, Cincinnati 15, Ohio.



Arkansas Power and Light Company, Helena, Arkansas. Over 50 carloads of Careytemp pipe and block insulation applied by B & B Engineering and Supply, Houston, Texas. Plant designed by Ebasco Services. Has Babcock and Wilcox boiler, Westinghouse Turbine.

For more data circle 513 on Post Card

Electrical Protection goes MODERN with BUSS Fuses...

in All-Electric Schools

Utica Michigan

• *Electricity* heats, lights, pumps water, cooks and operates all motor driven equipment in the West Utica and the Ewell Elementary Schools. No other utility service is used except the telephone.

The complete use of electrical energy puts special emphasis on the need to use the safest, most modern protective devices throughout the electrical system.

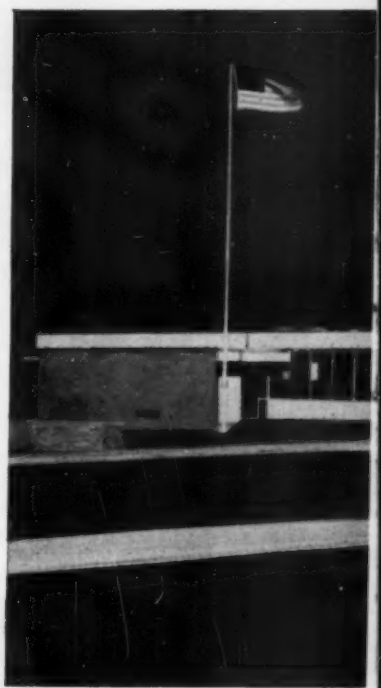
In each school, the main switchboard is protected by 3—1600 ampere BUSS Hi-Cap fuses having an interrupting rating of 200,000 amps. rms symmetrical. Thus, safe interruption of fault currents now available is assured,—and the fuses are adequately safe to allow for future system growth.

If a high fault current should occur, the fast opening characteristics of BUSS Hi-Cap fuses further protect the circuits and equipment against damage by restricting let-thru fault currents to safe value.

Feeder and branch circuit protection

To provide the safest short-circuit and overload protection . . . and to prevent needless outages,—FUSETRON dual-element fuses are used in the feeders and branch circuits of these schools.

For modern, all-purpose protection of circuits up to 600 amps., FUSETRON fuses cannot be equalled. They have 100,000 amp. interrupting capacity,—and sufficient time-lag to hold harmless overloads.



For more information on

FUSETRON dual-element fuses *. . . write for bulletin FIS*

BUSS Hi-Cap fuses *. . . write for bulletin HCS*

BUSSMANN MFG. DIVISION, ***McGraw-Edison Co.*** **St. Louis 7, Mo.**

EWELL ELEMENTARY SCHOOL

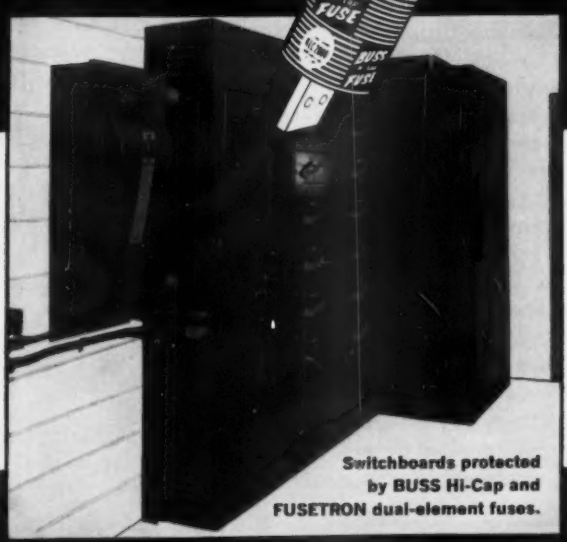
Architects—
SMITH & SMITH / ASSOCIATES
Royal Oak, Michigan

Consulting Engineers—
B. A. KING & ASSOCIATES, INC.
Birmingham, Michigan

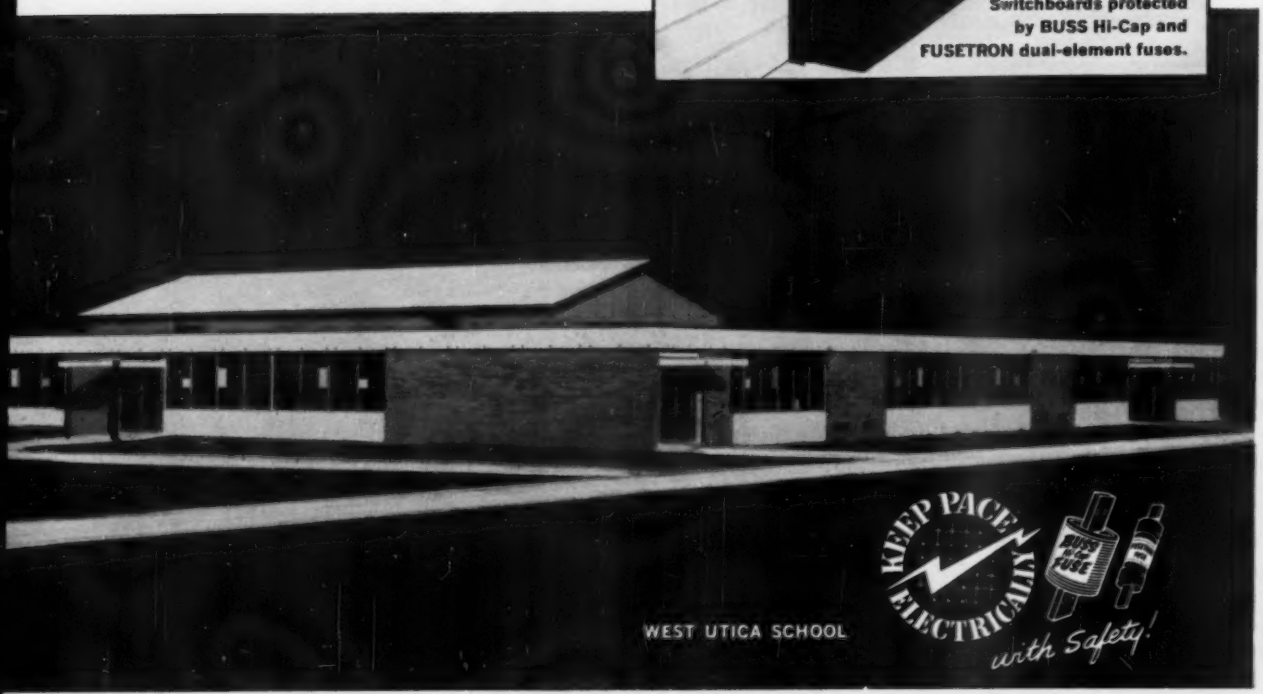
Electrical Contractors—
SCHEPER'S ELECTRIC CO.
Utica, Michigan

General Contractors—
Ewell Elementary School
GILBERT & KERNER
Utica, Michigan

West Utica School
CHISSUS CONSTRUCTION CO.
Birmingham, Michigan



Switchboards protected by BUSS HI-Cap and FUSETRON dual-element fuses.



WEST UTICA SCHOOL

KEEP PACE ELECTRICALLY with Safety!

For more data circle 514 on Post Card

Rockwell-Edward Nuclear

Shippingport, Pennsylvania, 1961: After more than three years of operation, it is possible to report in depth on the manufacture and performance of Rockwell-Edward high-pressure steel valves built for Shippingport, pioneer nuclear power generating station. This report deals with two areas:

1. *How Rockwell-Edward quality control met rigid Shippingport requirements.*
2. *How relatively standard design Edward valves have performed in Shippingport nuclear service since startup in 1957.*

Quality Control

Quality control of the highest order in building steel nuclear valves for the Duquesne Light Company-operated Shippingport Station brought the valve maker's art to new heights. These valves, for the primary coolant system in the first full-scale nuclear power generating station, were furnished by Edward Valves in 1-inch to 18-inch sizes. Since no valves had ever been called upon to perform in such service before and since slightest valve failure could have consequences far more serious than any possible before, Edward was called upon to apply every conceivable technique of quality control known.

From the very beginning, physical and chemical analysis of all component materials was made on every lot and every heat. Statistical lot testing was not adequate.

Testing and Measurement

Normal valve making requires only that certain diameters and angles be watched to critical tolerances. But for the Shippingport valves, every dimension that could be measured was measured and checked to tolerances of thousandths of an inch. All forged steel valve bodies were ultrasonically tested to pick out body flaws that could lead to leaks or stress concentrations. Ultrasonic testing is not ordinarily warranted for valves as small as 1-inch size. After Stellite inlays were laid and machined for seating surfaces, dye penetrants were used to detect porosity, surface flaws, holes and crevices.

All internal surfaces were inspected with a Boroscope. Roughness was held to 30 microinches.

Precision and Cleanliness

Though lapping is usually reserved for valves destined for gas service, the Shippingport valve seats were hand lapped to a maximum roughness of 16 to 30 microinches, rms. All internal surfaces exposed to fluid were polished to 125 microinches, rms. Such fine internal finishing is very difficult on small valves, but had to be done. All internal surfaces were inspected with Boroscopes.

All cleaning and degreasing as well as final assembly were done in the "clean room". All personnel wore lint-free coveralls. No smoking was permitted.

Final Tests

Two-hour hydrostatic tests, back seat tests, and packing tests were done in the "clean room," also. After tests, the completed valves were again oven dried in nitrogen and inspected with a Boroscope for cleanliness, porosity and surface finish. These inspections were made by Edward and representatives of Westinghouse Electric Corp. and the United States Navy. Valves were sealed in polyethylene bags and then removed from the "clean room" for packing according to military standards.

Experience with rigid quality control conditions such as these is hardly routine. But it illustrates what a valve maker can do with his standard line.

Performance Record

Not a single complaint has been received on any of the more than 100 Edward one-inch and two-inch forged steel globe stop valves used in the high-pressure primary reactor system, or on the four 18-inch tilting disk check valves used in the primary coolant pump discharge lines.

A few of the globe stop valves have required routine seat maintenance, but no more than would be expected. Leakage through the packing of the globe stop valves has been consistently within expected limits . . . that

Valve Report:

is, so minute as to be of no consequence. In fact, although many of the Edward globe stop valves were furnished with weldable caps as a precaution against packing leakage, the caps have been welded into place only on those valves in relatively inaccessible areas near the reactor.

Forged steel valves for Shippingport—and for the Westinghouse Belgian reactor and other nuclear projects—were individually sealed in plastic bags.

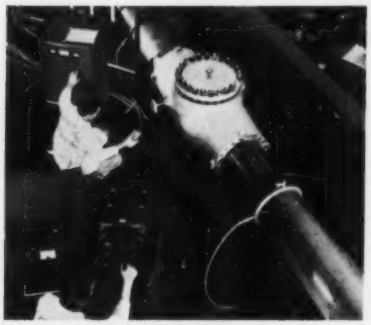
In furnishing high-pressure steel valves for virtually every U.S. nuclear power plant built to date, Edward has demonstrated that excellence of design and manufacture is *the* important ingredient in nuclear power valving, just as it has been in conventional power valving for more than fifty years. They have proved that there *are* important differences in various steel valve lines . . . and that Edward customers get the benefit of these differences.

Edward builds a complete line of forged and cast steel valves from ¼" to 24" for power, industrial, marine, and petroleum services. For more information, contact your Edward Representative, or write Edward Valves, Inc., 1202 West 145th Street, East Chicago, Indiana. Subsidiary of Rockwell Manufacturing Company. Represented in Canada by Lytle Engineering Specialties, Ltd., 438 St. Peter Street, Montreal.

This valve is typical of smaller capped forged steel stop valves furnished for Shippingport. Cap has been screwed into position on bonnet but has not been seal-welded.

Big Cast Steel Valves, Too

The development of suitable check valves for pump discharge service in primary coolant loops of large pressurized water reactors has been substantially advanced by exhaustive flow testing begun in the Edward research laboratories in the 1940's. Equipped with a flow test loop circulating up to 2,000,000 lb/hr of water and capable of flow reversal in a fraction of a second, Edward research engineers have been able to simulate actual service conditions and develop check valve designs with superior opening and flowing characteristics together with the best possible non-slam features upon flow reversal. Full size prototypes of Shippingport, N. S. Savannah, Enrico Fermi, and Indian Point primary loop check valves were tested with this equipment.



6104

Large 18-inch cast steel stainless steel check valves for Shippingport (left) received same meticulous attention as small forged valves . . . and have functioned with equal dependability since going into service in late 1957.

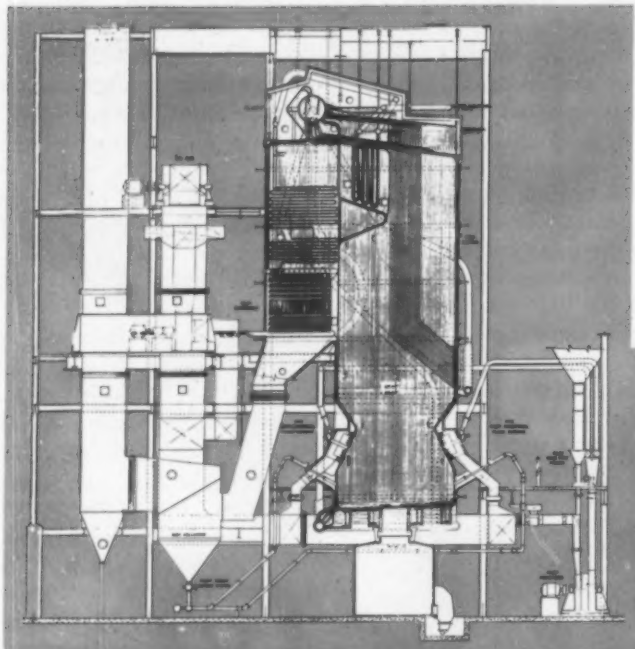
Other large Rockwell-Edward stainless steel valves were built for primary coolant systems of Babcock & Wilcox N.S. Savannah (center) and Indian Point (right) reactors.

EDWARD STEEL VALVES
another fine product by
ROCKWELL

For more data circle 515 on Post Card

RILEY TURBO FURNACE

...Has Appetite

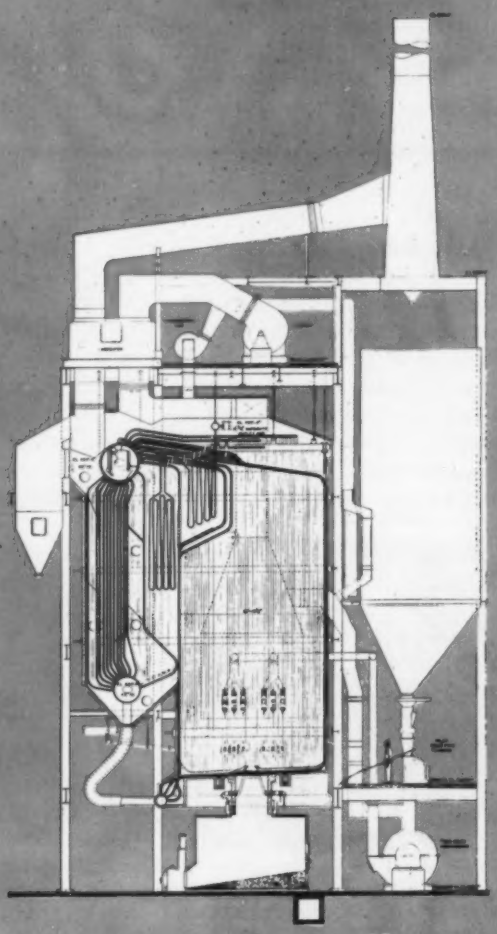


These four industrial type Riley Turbo Furnace Boiler installations demonstrate the exceptional ability of this exclusive Riley furnace design to utilize a wide variety of fuels.

The Turbo Furnace design efficiently utilizes waterwall surfaces producing rapid and uniform natural water and steam circulation. Uniform gas distribution produces minimum variation in superheater temperatures. Absence of excessive wall deposits reduces need for wall blowers.

PULVERIZED COAL

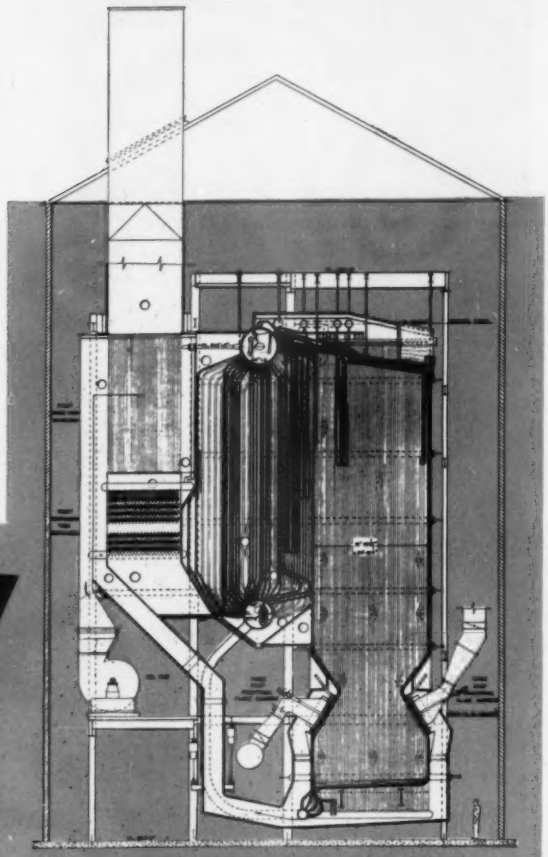
These two Riley Turbo Furnace Boilers for two large chemical companies each will fire coal pulverized by Riley 550 Pulverizers. The 650,000 lb/hr Turbo Furnace unit (above) is designed for a pressure of 1400 psig and a steam temperature of 900 F. Coal is pulverized by five Riley 550 pulverizers. Operating efficiency is 89.2%. The Turbo Furnace Boiler at right is designed with a steam capacity of 150,000 lb/hr at a pressure of 700 psig and a temperature of 760 F. Fired by two Riley 550 Pulverizers.



for Many Fuels

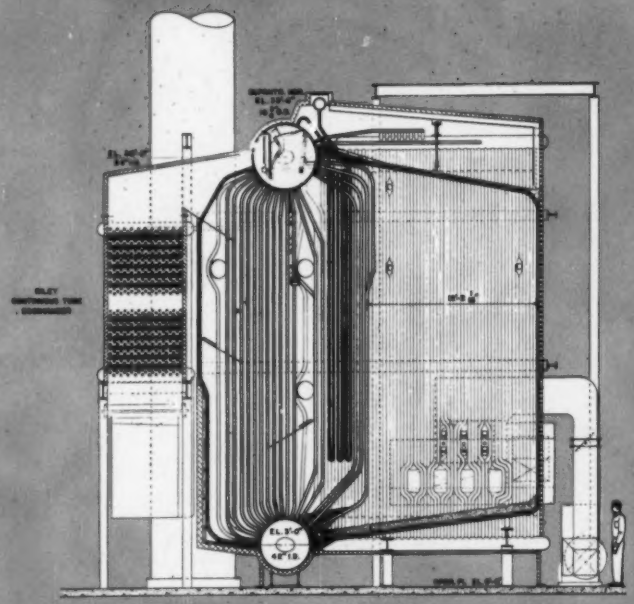
Carbon loss and flyash are kept to a minimum. Steam temperatures are maintained over a wide load range. Burners on one level make supervision easy and automatic operation convenient.

For further details about the unusual fuel burning capability of the Riley Turbo Furnace call your Riley representative or write direct to RILEY STOKER CORPORATION, Worcester, Massachusetts.



BLAST FURNACE GAS, OIL

A prominent steel producer is using this 350,000 lb/hr Riley Turbo Furnace boiler to burn blast furnace gas and oil. The unit is designed for a pressure of 975 psig with a steam temperature of 850 F and at an efficiency rating of 78.5%. The furnace is also pressurized.



CO GAS, GAS AND FUTURE OIL

Riley Turbo Furnace boiler unit for a Texas refinery will fire natural gas at 75,000 lbs/hr and at 50,000 lbs/hr capacity will fire catalytic flue gases which will help to reduce atmospheric pollution. The unit is designed for 450 psig and 650 F.

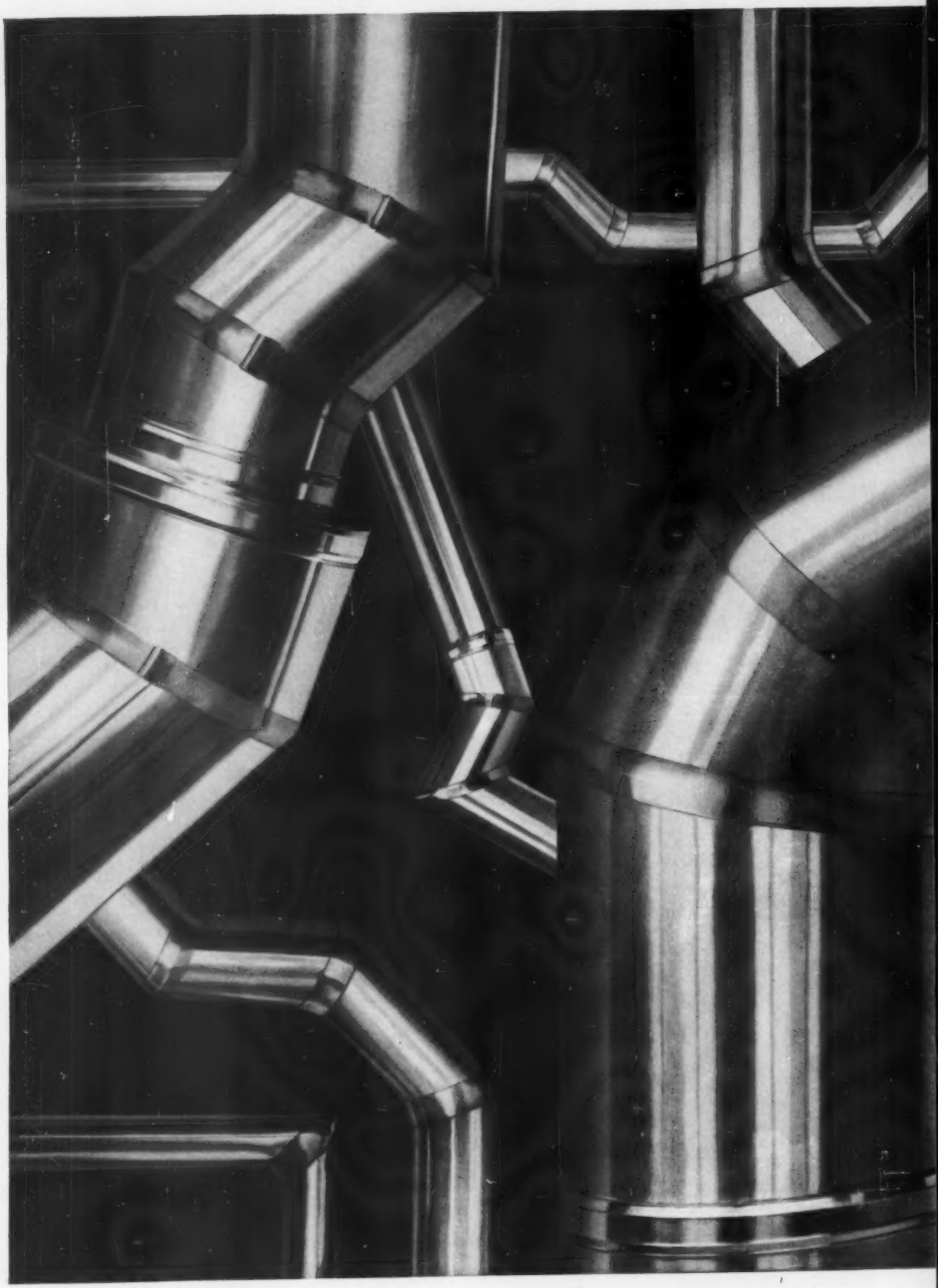
For Complete Details About Riley Boilers Write RILEY STOKER CORPORATION, WORCESTER, MASSACHUSETTS

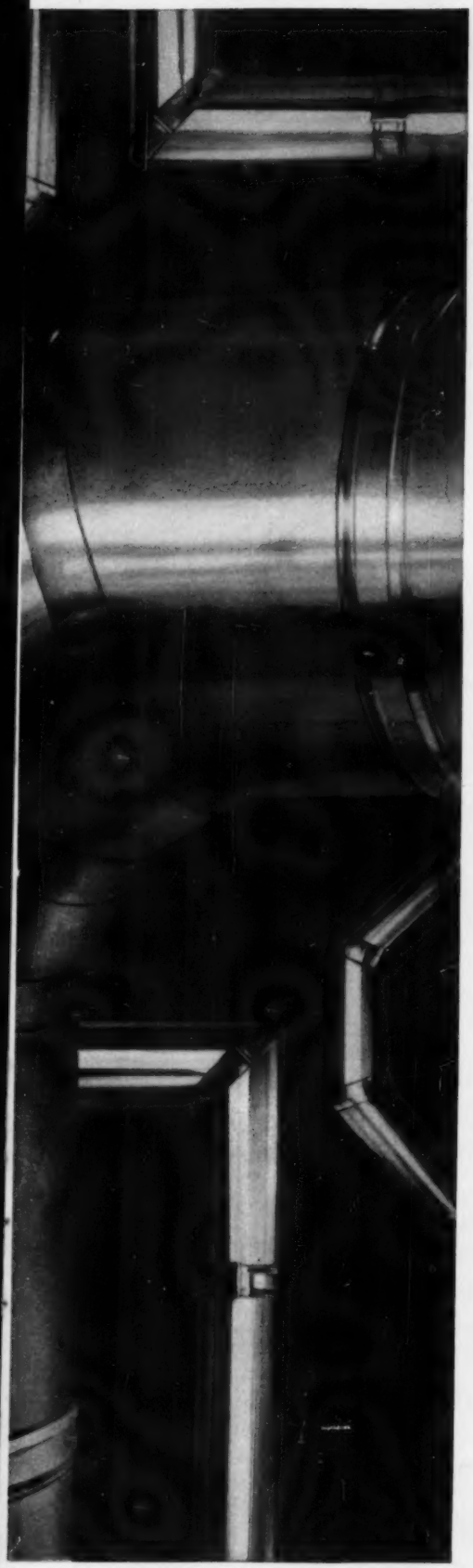
Sales Offices: Boston, Charlotte, Chicago, Cincinnati, Cleveland, Denver, Detroit, Honolulu, Jacksonville, Kansas City, Los Angeles, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Salt Lake City, San Francisco, St. Louis, St. Paul, Seattle, Syracuse.

RILEY

STEAM GENERATING & FUEL BURNING EQUIPMENT

For more data circle 516 on Post Card





Now! J-M Metal-On covers all the angles

WITH NEW J-M MITER-SEALS, YOU CAN USE METAL-ON TO INSULATE ELBOWS, BENDS, SWEEPS AND TURNS

Now you can protect your *entire* pipe-line system with Johns-Manville Metal-On®...the Thermobestos®, calcium silicate insulation prejacketed with weather-proof aluminum. Yes, even the most complex elbows, bends, sweeps and turns can benefit from the superior insulation of Metal-On.

J-M research has developed Miter-Seal®, a factory-made, preformed aluminum band. It has a clip at one end that can be tightened in a flash with a J-M Banding Wrench. *One* measurement, *one* cut, *one* application, and both insulation and jacket are applied. A quick turn of the Banding Wrench on the Miter-Seal completes the job! (See below.)

For full details, write to J. B. Jobe, Vice President, Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: Johnmanvil.

THE MATERIALS

Miter-Seal

J-M Banding Wrench

THE METHOD

Mitering section of Metal-On. Both jacket and Thermobestos are cut in one step with ordinary carpenter's saw.

Mitered section of Metal-On is placed on 90° fitting.

Miter-Seal sealing compound is placed in mitered joint.

Miter-Seal bands are applied and tightened to finish fitting.

JOHNS-MANVILLE

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

For more data circle 517 on Post Card

Lined against corrosion with gunited concrete

The lining being applied – of corrosion-resistant concrete made with LUMNITE calcium-aluminate cement and insulating aggregate – will soon be protecting stack and breeching from the corrosive action of flue gas condensate.

It will also keep stack gases hot, maintaining better draft for greater operating efficiency. Steel shells will stay cooler, extending exterior paint life. And monolithic concrete linings have lower unit weight, reducing dead load on supporting structure. Gunited or plastered, installation is easy and economical, with the concrete reaching service strength in 24 hours. For convenience, manufacturers of refractories offer castables bonded with LUMNITE cement – packaged mixtures ready to use by adding only water.

For more information, write Universal Atlas, 100 Park Avenue, New York 17, N. Y.

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ANOTHER ACHIEVEMENT IN MODERN FLOW CONTROL BY CRANE

CRANE PRESSURE-SEAL BONNET GATE VALVES

are built to meet the toughest demands of high pressure/temperature steam and power piping systems. Special metals—silver, stainless steel, chrome and Stellite* guard all critical valve areas:

1 chrome-plated retaining ring remains freeze-free for easy dismantling; 2 precision tapered silver-plated seal ring eliminates bonnet joint leakage; 3 stainless steel inlay in body insures tight sealing, maximum protection against corrosion; 4 Stellite-faced seating surface and seat rings are engineered for trouble-free, minimum-maintenance service.

Crane Pressure-Seal Bonnet Gate Valves are armored with special metals and careful engineering details. Full travel disc guiding prevents wear and drag on seating surfaces. Flexible wedge disc won't stick even when the valve is closed hot and opened cold. Valve yoke is mounted to the body, transmitting operating torque directly to the valve. The smooth flowing contour design allows straight-through flow with no turbulence.

These gates are your best bet for long, safe, dependable service.

Sizes 1" to 24"; 600-, 900-, 1500- and 2500-pound classes

*Stellite is a registered trademark of Union Carbide Corp.

All Crane Pressure-Seal Bonnet Valves are ASA-rated. Minimum metal thicknesses comply fully with the requirements of ASA B16.5–1957, the ASA Code for Pressure Piping and the ASME Boiler and Pressure Vessel Code.

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Nalco Treatment Technique Protects Non-Wetted Cooling Tower Sections from Microbiological Attack

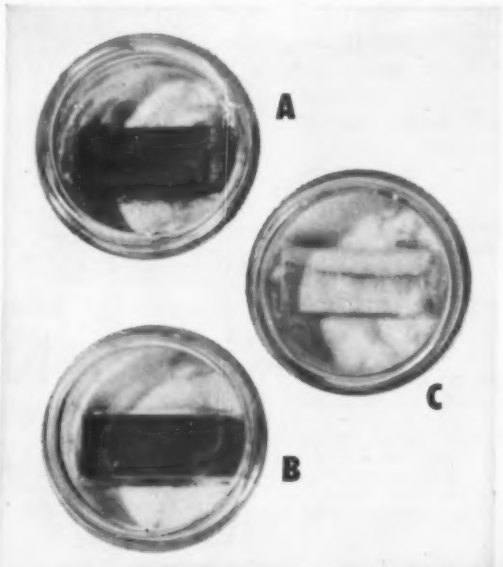
Simple, Low-Cost Method Delivers Effective Chemical to Non-Wetted Tower Areas

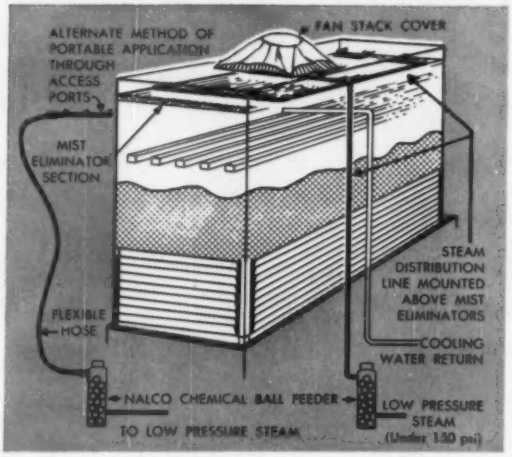
Tower sections above the water distribution level have presented a tough protection problem. Chemicals in the water rarely reach fan stacks, top decks, plenum chambers and mist eliminators in sufficient concentration to be completely effective. All of these areas are subject to damaging wood rot caused by microbiological attack. Consequently, a difficult manual spray method has been used to combat this problem. Nalco now recommends using a steam application method to carry powerful microbiocides into the non-wetted areas as a positive method of reaching *all* non-wetted surfaces. The technique is simple, low-cost, and has proved very effective in keeping non-wetted lumber rot-free.

How Steam Treatment Works

Fans are shut down, and fan stacks covered. It is possible to circulate water in the tower during steam treatment, but faster results can be had if circulation is also stopped. Low pressure steam is directed through a container of *Nalco* ball briquette microbiocide chemicals, which are carried with the steam. Perforated steam pipes, inserted into the plenum chamber, carry the steam chemicals into all spaces above the water distribution lines, permitting the chemicals to penetrate wood surfaces and providing protection against wood rot.

These test blocks were placed on a nutrient agar inoculated with a known wood rot organism. Test blocks A and B had been removed from a tower treated with Nalco steam spray. Test block C had not been treated. Notice extreme accumulation of fungal organisms on untreated block C.




ALTERNATE METHOD OF PORTABLE APPLICATION THROUGH ACCESS PORTS
FAN STACK COVER
MIST ELIMINATOR SECTION
STEAM DISTRIBUTION LINE MOUNTED ABOVE MIST ELIMINATORS
FLEXIBLE HOSE
COOLING WATER RETURN
NALCO CHEMICAL BALL FEEDER
LOW PRESSURE STEAM
TO LOW PRESSURE STEAM
(Under 150 psi)

Typical installation of the Nalco steam spray system.

Portable or Permanent?

A number of Nalco-treated cooling towers have been equipped with permanently-installed steam pipes for microbiological control. Others are treated with steam lines and feeding equipment which is put in place for treatment, but moved from tower to tower as needed. Either way, this Nalco technique is providing a degree of economical protection that controls the wood rot hazard, removing it from the list of operators' problems.

Follow-Through Assistance

Your Nalco Representative will be glad to give you details on how your cooling tower non-wetted sections can be protected effectively; and tell you whether your towers need this treatment now. If steam treatment is indicated, he will help set up the necessary equipment, supervise application to assure results, and make periodic checks on the continuing effectiveness of the treatment.

Chemical microbiocides used for steaming are compatible with other *Nalco* chemicals used in cooling towers for stabilization, water-borne microbiological control, and scale and corrosion control. Your Nalco Representative is an expert in this area, too . . . Use his knowledge and experience—backed by the world's largest water treatment service organization—to solve *all* your cooling water treatment problems. Call him today, or write direct, for Prints 264, 265 and 266 which define steam spray application.

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Current Catalogs

New and revised publications reviewed on these pages offer help on operating and maintenance problems. To order, use the handy Reader Service Post Cards provided on pages 99 and 100.

Electrical

101 Synchronous Motors—Performance, dependability and lasting economy of company's low speed synchronous motors are discussed in Bulletin 502, 12 pp, by Ideal Electric and Mfg. Co. Includes construction details, modifications, application data chart. Illustrates typical installations.

102 Wound Rotor Motor—In Bulletin 104 The Louis Allis Co. describes a wound rotor motor, in sizes 1 to 30 hp, in open, drip-proof or totally enclosed, non-ventilated enclosures for horizontal, ceiling or wall mounting.

103 Dry-Type Transformers — Single phase, three phase and phase changer transformers are detailed in Atlantic Transformer Co.'s two-color Bulletin 102-261, 36 pp. Wiring diagrams, and specifications included.

104 Disconnecting Switches—Selection data on hookstick and group operated, 7.2- to 345-kv outdoor disconnecting switches is offered by Westinghouse Electric Corp. in 20-pp Descriptive Bulletin 36-250. Covers construction and applications of switches, which include single- and double-throw, single and multiple types with manual or electrical operating mechanisms.

105 Circuit Breaker Selector — To facilitate choice of proper size and type breaker in the AB De-ion line, Westinghouse Electric Corp. offers this 7-in. selector disc. It covers six basic types. By rotating and matching top and bottom sections of the disc, you can determine both physical and electrical characteristics of the breakers in various types and sizes.

106 Oil Circuit Breaker—Advantages of Allis-Chalmers Mfg. Co.'s five-cycle Type OZ distribution oil circuit breaker for 14.4 and 23 kv is described in 8-pp Bulletin 71B9705. Construction features are illustrated and dimensions and ratings tabulated.

107 Space Saving Relay—Advantages of General Electric Co.'s 10-amp 300-v relay which cuts panel space requirements and provides own wiring trough are detailed in 12-pp Bulletin GEA-7329. Includes ordering information, outline drawings.

108 Panel Instruments — Matched panel instruments in d-c. rf, and a-c rectifier types and in moving iron a-c types are described in 6-pp Bulletin 01-111 by Daystrom, Inc. Includes data on dimensions, availability of shielded and unshielded types, accuracies, power consumption, and expanded scale types.

109 Coupling Capacitors — Two companion bulletins on coupling capacitors and potential devices are announced by General Electric Co. Bulletin GEA-7232 covers advantages and applications of coupling capacitors and includes ratings, dimensions and diagrams. Bulletin GEA-7233 covers performance characteristics of coupling capacitor potential devices

110 Power Fuse Selection Guide — Application and selection of high-voltage power fuses are described in Westinghouse Electric Corp.'s 16-pp booklet, Application Data 36-660. Covers information on interrupting ability, continuous current ratings, and melting characteristics.

111 Interchangeable Bushings—Design and applications of condenser bushings which can be interchanged between transformers, circuit breakers and bushings of other manufacturers are detailed in 10-pp Booklet MB-1928 by Westinghouse Electric Corp.

112 Electrical Instruments — Form 35M, 32 pp, catalogues Keithley Instruments, Inc.'s line of instruments, including electrometers, micro-microammeters, microvolt-meters, regulated high voltage supply, and high megohm bridge. Applications, specifications and prices provided.

113 Flexible Wiring Conduit—Bulletin S-544, Anaconda Metal Hose Div., covers diameters, weights and specification data of four types of Sealtite liquid-tight wiring conduit.

114 Terminal, Splice Selection—Improved method of computing exact terminal or splice barrel size required for any given size of solid, stranded, rectangular or square wire (singly or in combination) ,from No. 26 to 1,000,000 cm is explained by Amp, Inc., in this 8-pp catalog. Technique involves measurement of circular mil area of wire in cross section.

115 Rigid PVC Conduit — In this 8-pp bulletin, Lasco Industries describes rigid PVC plastic pipe, UL approved for use as electrical conduit. Specifications and suggested applications are provided. Also shown are coupling, elbow expansion joint and adapter shapes.

Mechanical Power Transmission

116 Drive Selection Guide—Bulletin 70, by Dodge Mfg. Corp., gives a simplified method for selecting Flexidyne dry fluid drives and couplings. Includes tables of weights, dimensions, prices, and recommended V-belt drives for various drive sizes.

117 Gear Speed Reducers—Catalog 42C, 24 pp, by D. O. James Gear Mfg. Co., is a handbook on single reduction, right-angle spiral bevel gear reducers of horizontal and vertical design, providing formulas for selection and a guide for determining load characteristics. Specification tables, rating charts and dimensional drawings are also provided in the catalog.

118 Air-Actuated Clutches — Benefits of designing or modernizing heavy-duty grinding mills with air-actuated clutches are detailed in Bulletin ML-199 by Fawick Corp. Outlines such benefits as smooth start-up, prevention of electrical circuit overload, reduced peak power demand.

Valves, Piping, Fittings

120 Control Valves—Comprehensive selection data on pneumatic diaphragm and piston actuators, and discussion of valve body components and materials are presented in 64-pp Bulletin E-600 by Fisher Governor Co. Detailed section on control valve specifications includes illustrations to facilitate selection of control valve for specific application, pressure-temperature ratings, pressure drop tables, performance data and frequency response.

121 High-Pressure Valves—Bulletin BV/HP1 describes available sizes, materials, pressure-temperature ratings and applications of high pressure ball valves of Pacific Valves, Inc. Data on "fire-safe" ball valves, high pressure Stelock ball seals, fire safe stem packing and body gaskets, and a resume of the physical properties of Nylon and Delrin are included.

122 Control Valves—Bulletin 709.22 by Republic Flow Meters Co. describes diaphragm-actuated Type V5 control valves designed for high pressure service on steam, water, oil or gas. Specifications and diagram included.

123 Water Relief Valves — Watt Regulator Co.'s ASME-rated pressure-only relief valves are described in brochure F-ASME-1961, 8 pp. Installation diagrams, rating tables, sizes and capacity ranges included.

124 Ammonia Valves — Some 292 valves and accessories for ammonia refrigeration, L-P gas service, and other applications are described by Henry Valve Co. in 12-pp Catalog 203. Cutaway views showing features of construction and specification charts are included.

125 Reinforced Plastic Pipe—Three bulletins offered by Fibercast Co. present this cast thermoset epoxy resin,

Current Catalogs

glass reinforced pipe as a solution to pressure and corrosion problems. A 12-pp booklet describes the pipe, its industry applications and physical properties. A folder deals with Fibercast pipe in structural use, such as communications towers. A third book, 16 pp, provides detailed technical and specification data, including tables of corrosion resistance.

126 How To Select Couplings—Simplified selection of quick connect/disconnect couplings is possible with 62-pp Catalog 60A of Snap-Tite, Inc. Covers several hundred combinations available. Also provides a packer usage guide listing some 575 fluids and gases and suggesting types of seals to be used with them. Construction details, dimensional and weight data included, also working pressures, flow, pressure drop and spillage data.

127 V-Band Coupling Economies—Sixteen-page Booklet SDP-2, "Economics of the V-Band Coupling," by the Marman Div. of Aeroquip Corp., gives cost comparisons between V-bands and other joining methods. Explains how hidden manufacturing costs can be reduced. Savings in weight, installation and assembly time illustrated.

128 Flexible Connectors — Manual AM-9, 16 pp, by Allied Metal Hose Co., analyzes flexible pipe connectors, their application, design and handling. Sections cover: analysis, interpretation of specifications, how to avoid failures, installation and ordering checklist.

Lubrication

129 Industrial Lubricants—In this 16-pp booklet, Pure Oil presents a six-step lubrication service. Tells how company establishes a plant's basic requirements; provides individual machine schedules; establishes inventory control plan; trains staff to administer program; sets up record system; tests oil in use. Book also describes available types of machine oils, engine oils, cylinder and heavy mineral oils, gear lubricants, greases, others.

130 Lubrication Selection—Recommendations for lubrication of various types of machinery and equipment are presented in Bulletin LMF-61 by Lubriplate Div., Fiske Brothers Refining Co. Lists lubricants from lightest fluids to heaviest greases for specific applications.

131 Premium Lubricant—This comprehensive 20-pp booklet, by Hercules Packing Corp., discusses basic concept of molybdenum disulfide additive employed to enhance temperature capabilities. Contains charts diagraming reduction of frictional resistance between moving parts and sections on functional operation, physical properties and practical application.

Instruments and Controls

132 Telemetering Explained — Bulletin GEA-7163, by General Electric Co., describes the use and applications of telemetering and transistorized analog systems. Includes data on adaptability, flexibility and specifications.

133 Centralized Controls — Twelve-pp Bulletin C-6300 of Monitor Controller Div., Atlee Corp., is an easy guide for laying out and designing special or standard control centers. Describes features, and gives specifications, selection tables and optional modifications or additions.

134 By-Pass Rotameters—Economical measurement and control of large flow in pipe up to 48 in. is described by Brooks Instrument Co. Inc. in Bulletin 116, 8 pp. Covers capacity determination, flow, and piping requirements.

135 Pressure Gages — Bulletin 280 of American Standard Controls Div. describes pressure gages in 3- and 5-in. dial sizes designed to withstand overload pressure, vibration, shock or line pulsation. Gives pressure range, figure intervals, specifications.

136 Pneumatic Current Controller —Data Sheet 104, Conoflow Corp., describes a final control element — a pneumatic-electric transducer affording automatic regulation of current, voltage, resistance, inductance and capacitance. Illustrates models capable of handling hundreds of combinations of electrical components.

137 Pneumatic Temperature Transmitter — Described in 12-pp Bulletin 13-17C by The Foxboro Co. is a pneumatic temperature transmitter featuring force-balance operation. Includes specifications, description of operating principle, table of temperature ranges, and data on related accessories.

138 Industrial Gas Regulator—Form ADC 705G, 40 pp by Air Reduction Sales Co., covers gas precision regulators and accessories. Provides quick reference charts indicating variety and range, and a cross-referenced, illustrated layout.

139 Draft Control — This 32-pp technical brochure, "Control of Draft in Gas-Fired Equipment," is available from Field Control Div., Conco Engineering Works, Inc. Explores common draft-related problems: draft shortages and excesses, boiler capacity losses, dual-fuel installations, converted equipment, automatic switches. Includes basic story of why draft is required, why it varies, control.

140 Digital Data System—Bulletin 7110, by Monitor Systems, Inc., describes a system for measurement of voltage, demand, wattage, var and temperature quantities at remote substations and telemetering of information in digital form to central recording station. Block diagram and specifications included.

141 Peripheral Computer Equipment — Described in 8-pp Catalog SP-140 by Packard Bell Computer Corp. are peripheral units for plug-in connection to the PB250, digital computer. They include tape units, high-speed buffer, paper tape reader, paper tape punch, card reader, digital graph recorder, analog-to-digital and digital-to- analog converters, etc.

Maintenance

143 Compounds and Coatings — In DEL Bulletin 106, 16 pp, David E. Long Corp. describes recent developments in synthetic rubber compounds and protective coatings. Provides descriptive and application information on both the rubber compound and various types of coatings . . . vinyls, epoxies, acrylics, alkyds. Includes resistance chart.

144 Steam-Detergent Cleaning — Methods and materials used in steam-detergent cleaning are described in this product bulletin by Oakite Products, Inc. Contains details on steam-detergent gun and pistol and on various detergents for steam cleaning.

Boilers, Heat Exchangers

145 Vertical-Unit Boiler — The Modular VU-60 boiler of Combustion Engineering, Inc., is decribed in 6-pp bulletin, showing design highlights, characteristics curve and temperature traverse.

146 Standardized Heat Exchangers —Removable tube bundle heat exchangers with externally packed floating head are described by Basco, Inc., in 6-pp Bulletin 0-1162. Cut-away photos and drawings show construction. Sizes, dimensions and specifications for two types covering shell diameters 6—32 in. provided.

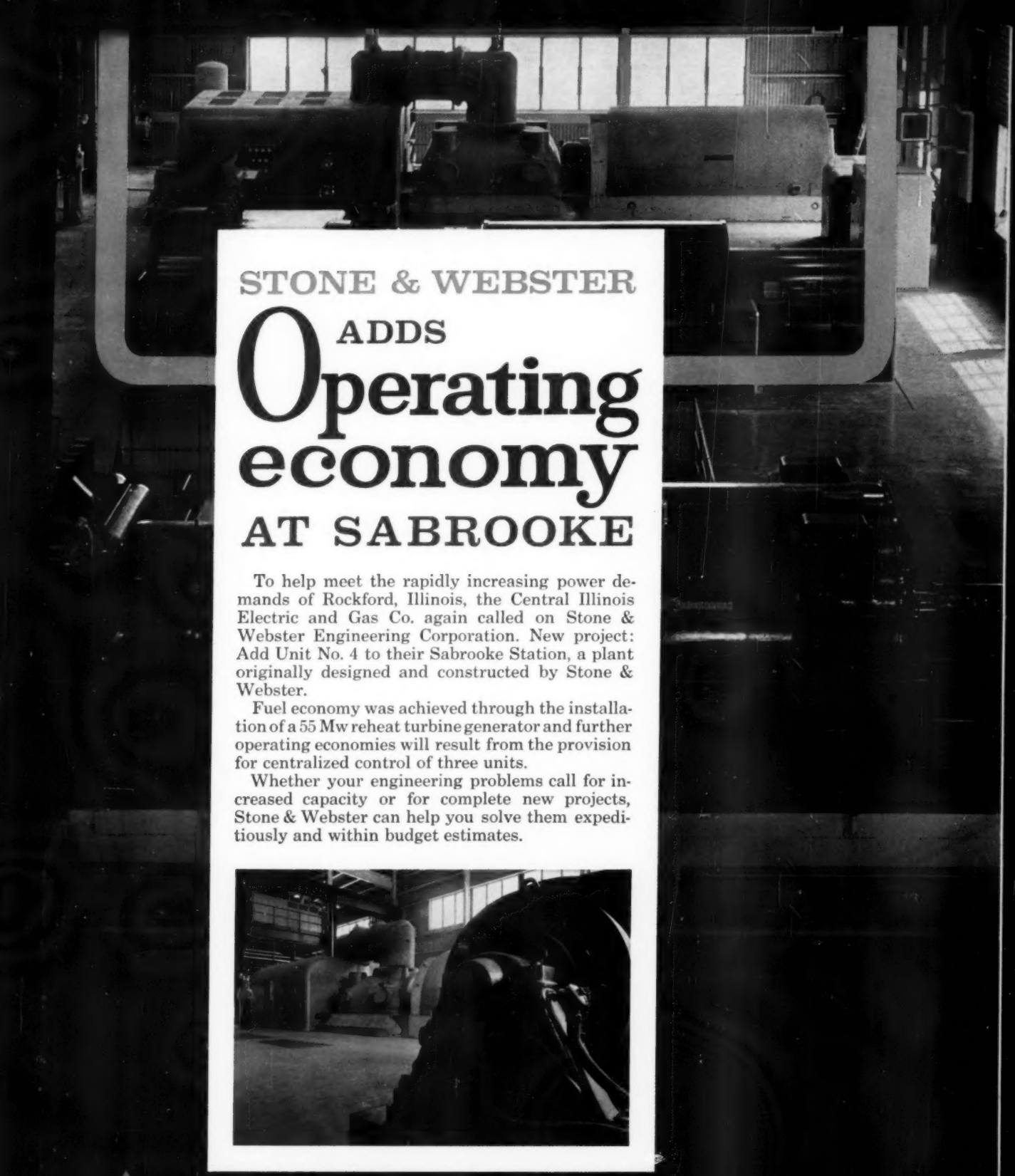
147 Finned Tube—Scovill Mfg. Co., in an 8-pp illustrated bulletin, introduces finned heat transfer tube, integral low fin type. Gives dimensional data, specifications, alloys and tempers, applications. Explains how finning multiplies effective heat transfer surface of the tube; discusses other design and installation advantages afforded in new and existing heat transfer units.

Dust Control

148 Dust, Fume Control—Effective methods for controlling industral dust and fumes are described by Pangborn Corp. in 20-pp Bulletin 922A. Provides brief explanation of advantages available through proper dust control and lists essentials of a typical system. Includes details on electric furnace exhaust hood and a collector suited for high-temp, corrosive gas applications.

149 Electronic Air Cleaners—Heavy-duty electronic air cleaners with push-button automatic control are described in 6-pp Catalog 1435 of Westinghouse Electric Co. Sections are devoted to principles of electronic air cleaning, construction features, selection details and specific application arrangements.

more Current Catalogs page 99



STONE & WEBSTER

ADDS Operating economy AT SABROOKE

To help meet the rapidly increasing power demands of Rockford, Illinois, the Central Illinois Electric and Gas Co. again called on Stone & Webster Engineering Corporation. New project: Add Unit No. 4 to their Sabrooke Station, a plant originally designed and constructed by Stone & Webster.

Fuel economy was achieved through the installation of a 55 Mw reheat turbine generator and further operating economies will result from the provision for centralized control of three units.

Whether your engineering problems call for increased capacity or for complete new projects, Stone & Webster can help you solve them expeditiously and within budget estimates.

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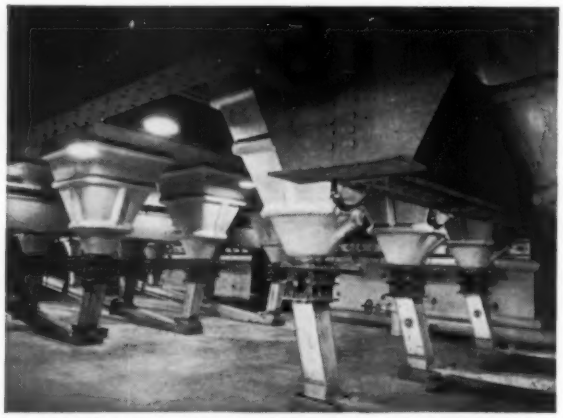
How Commonwealth Edison Turned a Fly Ash Problem Into Profit

At Commonwealth Edison's State Line Station, about 350 tons of fly ash a day had to be wet down, loaded, and trucked to suitable dumping sites.

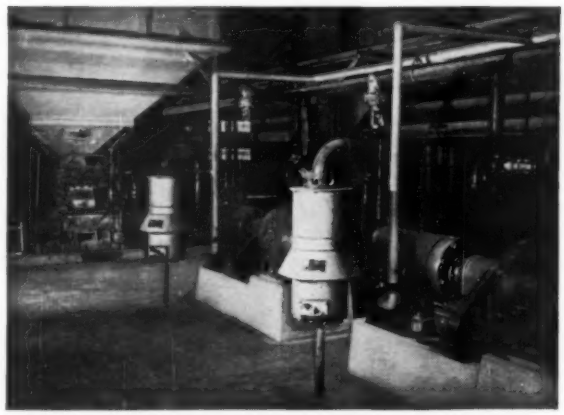
Waste becomes profit. Today, the plant burning a peak load of 5000 tons of coal daily collects dry fly ash automatically in a totally enclosed Fuller-Kinyon system. The ash is conveyed from precipitators to storage bins and silos, where it's sold as a by-product. Manpower: just three men, one at the main control panel and two bagging the ash.

Air and gravity do the work. F-H Airslide® conveyors fluidize dry fly ash by a column of low-pressure air for easy movement by gravity to central surge hoppers. Then, a Fuller-Kinyon pump under each hopper drives the ash by air through a five-inch line to storage. The system is practically maintenance-free. There are few moving parts to foul or wear out.

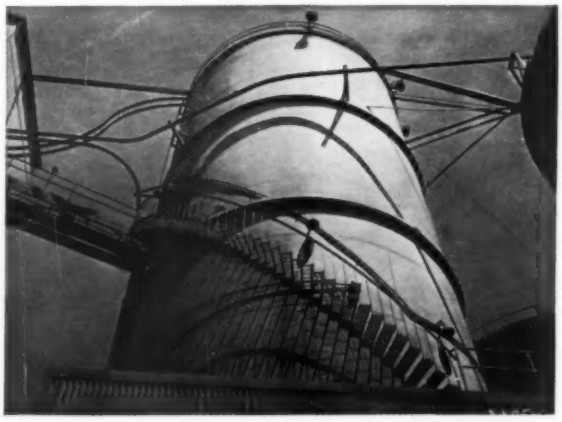
Large and small plants can get the benefits of Fuller-Kinyon fly ash handling. Capacities range from 100 to 8,000 cubic feet an hour. F-H Airslide and Fuller-Kinyon conveying lines can be curved to avoid beams and other obstacles. Low-pressure air provides power inexpensively and installation costs are significantly less than other types of conveying systems. Write for detailed information in Bulletin FF-49-1.



F-H AIRSLIDE FLUIDIZING CONVEYORS ANGLE DOWNWARD from precipitator hoppers, move air-activated ash to 20-ton central surge hoppers under floor. There are few moving parts.



FULLER-KINYON PUMPS AND COMPRESSORS under surge hoppers propel ash to bins and silos at 20 tons an hour. Fluidized by air, the abrasive, 300°F. ash moves without injuring system.



BULK SILOS receive air-conveyed ash through Fuller-Kinyon pipe-lines. Farthest silo is 1,000 feet from pumps. Over 50% of fly ash is bagged and sold as a by-product.

1335A
G-203 A

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GET LOW-COST DEPENDABLE PROTECTION FOR LOW PRESSURE BOILERS WITH AN H20® CHEMICAL METERING PUMP

Benefits include lowest cost ever, a new record for low maintenance requirements, and easier servicing. The H20 controlled volume pump not only costs less to purchase and install, but it costs less to operate at the peak of efficiency than any other comparable chemical feeder. The H20 metering pump is based on the same principles that have made Milton Roy controlled volume pumps famous. But in the interests of economy, every working part has been simplified and redesigned for production line manufacturing. There's been little sacrifice in accuracy, and none at all in dependability.

Around the clock, you can depend on your H20 pump to meter the necessary mild, non-corrosive treatment chemicals to your boiler feed, cooling tower and process make-up water. The H20 is available immediately from stock. Even completely piped and assembled chemical feed systems with simplex or duplex H20 pump and 50 to 100 gallon steel tank can be shipped within 24 hours. They're ready to go to work immediately, accurately and economically metering chemicals against pressures to 600 psi.

GET COMPLETE FACTS *on the H20 pump and packaged chemical feed systems in Bulletin 558. Write Milton Roy Company, 1300 East Mermaid Lane, Philadelphia 18, Pennsylvania.*

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Why a Steam Trap Has To Handle "Air"

Low temperatures and corrosion of equipment are often evidence of inadequate trap air venting capacity

Air, with its load of oxygen and carbon dioxide, has an unwholesome habit of interfering with the efficiency of steam heated units. If steam were always free of these undesirable companions, things would be a lot simpler for men-who-operate-plants. Because it isn't, three unhappy situations frequently occur:

1. ***Operating temperatures are subnormal.*** This is a two-part problem. First, an air-steam mixture has a lower temperature than pure steam at the same pressure—see Table A. Secondly, air can "plate out" on heat transfer surfaces as shown in Figure 1. Under some conditions, such an air film will knock down heat transfer efficiency by as much as 50%.

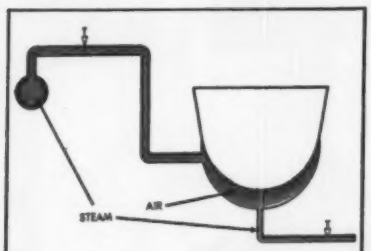


Fig. 1. *How air can "plate out" on heat transfer surfaces. This "insulation" drastically reduces heat transfer efficiency. Armstrong trap operation creates turbulence in the equipment that prevents this.*

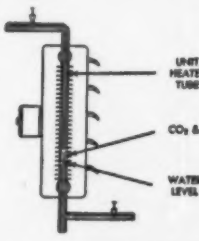


Fig. 2. *Corrosion occurs when units are not kept continuously free of both condensate and air. Armstrong traps discharge both,* at steam temperature, *as fast as they accumulate.*

2. ***Corrosion rears its ugly head.*** Oxygen and carbon dioxide are real trouble-makers. CO_2 gas goes into solution in condensate, forms carbonic acid and chews away at vulnerable metal sections. O_2 aggravates the situation. See Figure 2.

TABLE A—How air reduces steam temperature.

Gauge Pressure	Temp. of Steam with No Air Present	Temp. of Steam Mixed With Various Amounts of Air (% Air by Volume)	
		10%	30%
10.3	240.1	234.3	220.9
25.3	267.3	261.0	246.4
50.3	298.0	291.0	275.1
75.3	320.3	312.9	295.9
100.3	338.1	330.3	312.4

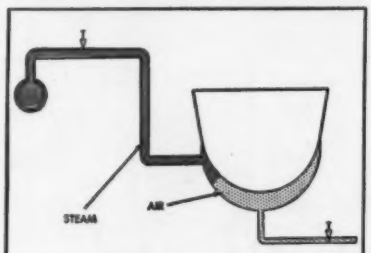


Fig. 3. *When steam is turned on, it takes a trap with extra air venting capacity to provide fast heat-up.*

3. ***Heat-up is slow as a snail.*** Air has a picnic in units that are shut off periodically. Figure 3 pictures the problem. Lines and equipment literally fill up with air. When the steam is turned on it can get in only as fast as the air gets out.

Enter Steam Traps

Curing these steam system ailments involves an operation sometimes called a "trap transplant." It consists of removing traps that don't get the air out and replacing them with traps that do.

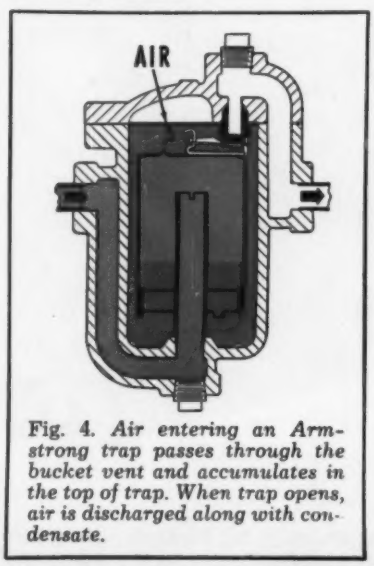
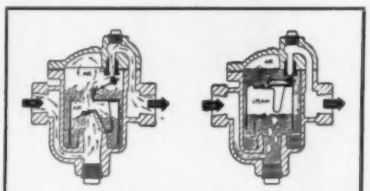


Fig. 4. *Air entering an Armstrong trap passes through the bucket vent and accumulates in the top of trap. When trap opens, air is discharged along with condensate.*

Figure 4 shows how an Armstrong inverted bucket trap continuously vents air. What the picture doesn't show is a built-in plus-value of this trap's design. An Armstrong trap opens suddenly, creating a momentary pressure drop and turbulence in the unit being drained. This breaks up air films and "pumps" air down to the trap so it can be vented.

The vents in standard Armstrong trap buckets will pass all the air normally encountered. In special cases, such as paper machine dryers, the vents are correctly sized larger at the factory to meet the requirement.



Thermostatic vent open. *Thermostatic vent closed.*

Fig. 5. *Open float with thermostatic vent for off-and-on units. When trap is cold, vent is open, permitting air to blow through when steam is turned on. When steam reaches trap, heat closes thermostatic vent. Then, regular bucket vent handles all air coming in with steam.*

Open Float with Thermostatic Vent

Super air-venting capacity is a must for fast heat-up of low pressure unit heaters, heating coils, steam headers and other units that are on-and-off. Figure 5 shows how the Armstrong open-float-with-thermostatic-vent trap takes care of this.

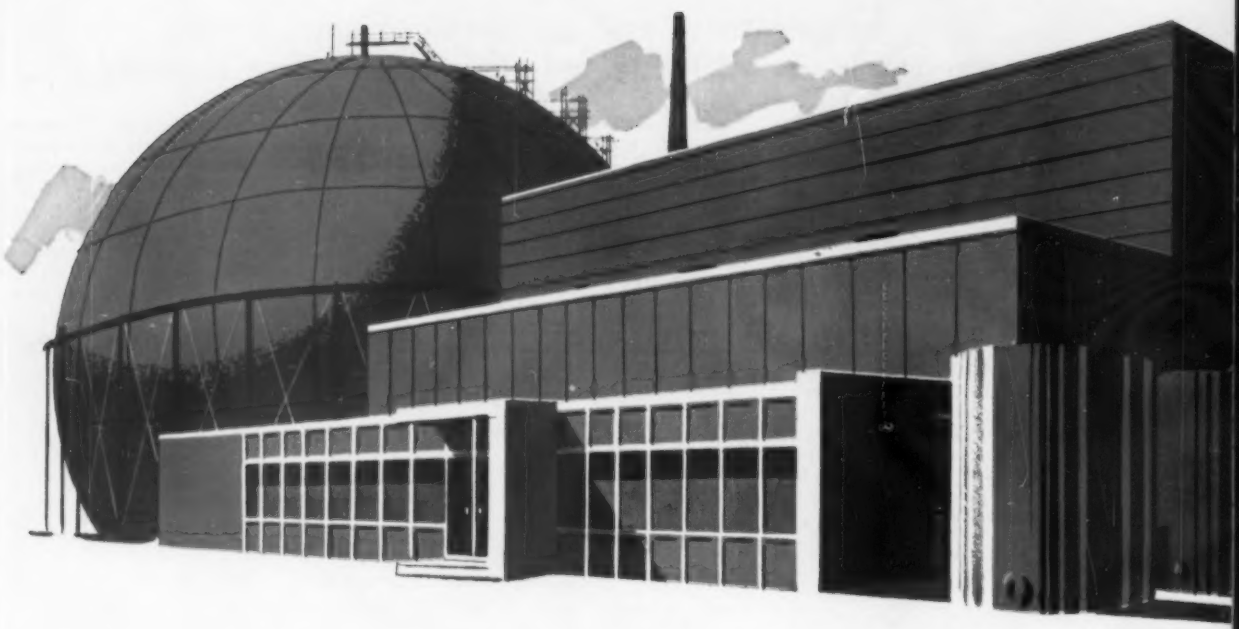
* * *

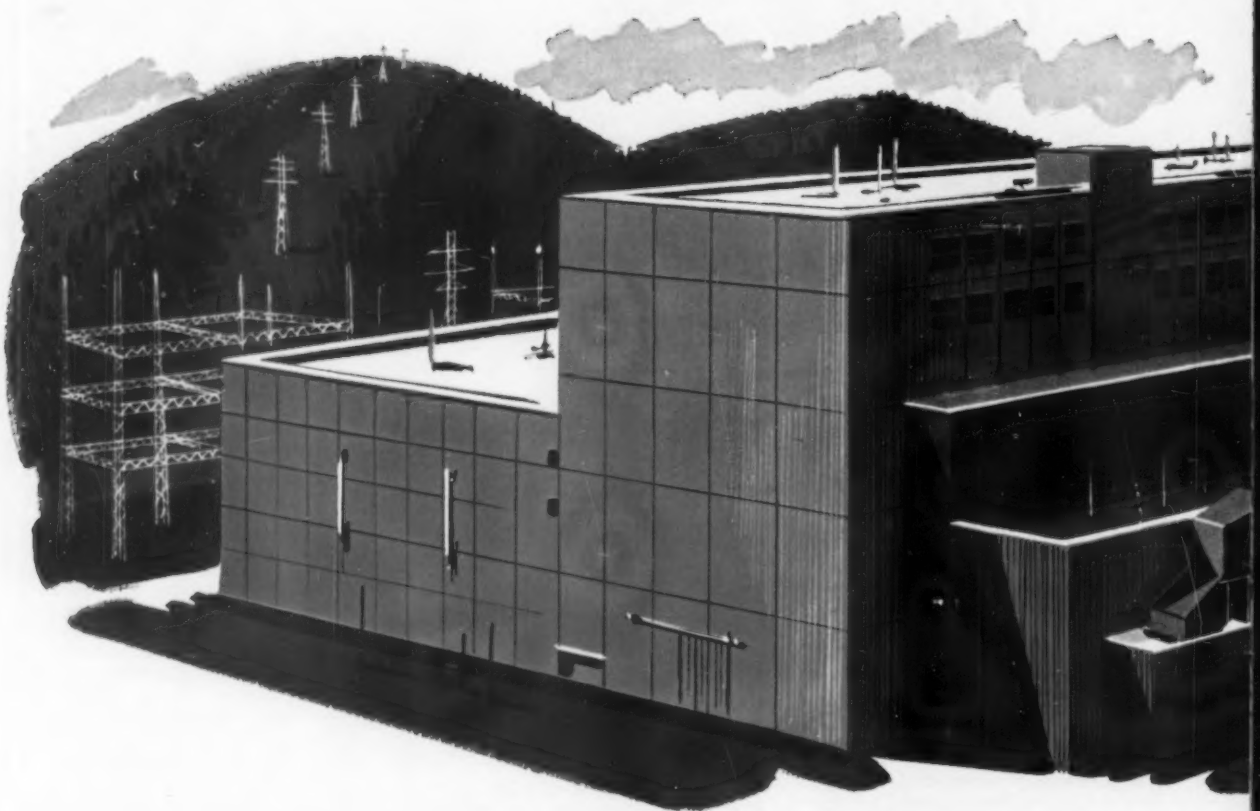
The 44-page Armstrong steam trap book covers other features of the Armstrong trap as well as its excellent air handling characteristics. This catalog also discusses trap selection, installation and maintenance. Your local Armstrong Representative or Distributor will be glad to give you a copy. Call him, or write Armstrong Machine Works, 8107 Maple Street, Three Rivers, Michigan.

ARMSTRONG STEAM TRAPS

See Our Catalog in Sweet's Plant Engineering File

For more data circle 525 on Post Card





POWER PLANT PRODUCTS HEAT ENGINEERED BY FOSTER WHEELER:
Central Station and Industrial Steam Generators • Steam Condensers and Pumps • Cooling Towers
Pulverized Fuel Systems • Feedwater Heaters • Packaged Steam Generators • Nuclear Components

Whatever the challenge

Atomic power plants were not achieved overnight. In a large measure they were built on fundamental knowledge developed for conventional steam power plants.

Thoroughly grounded in these fundamentals, Foster Wheeler has designed, engineered and built more nuclear steam generators than any other firm in the world.

Today, nuclear-born technology at Foster Wheeler contributes directly to superior equipment of every description . . . equipment that earns a better return on plant investment.

Foster Wheeler designs and builds utility, industrial and marine steam generators; pulverized fuel systems, steam condensers, feedwater heaters, nuclear components, cooling towers, pressure vessels, oil refineries; chemical, petro-chemical and industrial processing plants. Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, New York.

FOSTER WHEELER

NEW YORK TORONTO LONDON PARIS MILAN TOKYO

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IF YOU WANT SUPERIOR PRECIPITATOR PERFORMANCE

A precipitator is a lifetime purchase. Once it is installed, you must live with it, whether you like its habits or not. Because of that Buell urges you to look for the following features when you are making the major investment represented by an electric precipitator.

CONSTRUCTION

1. Custom designed, flexible—Buell helps you determine your precipitator needs, then designs a unit specifically for your requirements. Since Buell SF Precipitator sizes change by only 16″ increments, you can get exactly the size you need, without compromise of size, space, and cost.

2. Simplified erection—Modern construction and assembly-marked components and a design that facilitates simple installation, make Buell SF Precipitators easy to erect without specialized contractors. Erection is supervised by Buell engineers, to ensure satisfactory operation.

3. Rugged construction—Simple, rugged construction gives you high efficiency, combined with negligible maintenance costs.

GAS FLOW

4. Uniform gas distribution—Buell designs the entire gas system for its precipitators—including connecting flues with adjustable turning vanes if needed. In addition, at the inlet, special field-adjusting baffles ensure uniform flow across the entire face of the unit. Buell has complete laboratory facilities to determine dust or gas flow pattern with specially constructed three dimensional precipitator models.

ELECTRICAL SYSTEM

5. Fool-proof power supply—Buell silicon rectifiers are compact, lightweight, highly efficient. They need no maintenance—another reason for the top performance of a Buell SF Precipitator.

6. Rigid suspension—The emitting frame of a Buell SF Precipitator is hung from four temperature and shock resistant quartz insulators, each sealed in an individual heated compartment. With this rigid system, electrical distance from emitting to collecting electrode is held constant. This produces uniformly high emission for peak efficiency.

7. Peak emission—Exclusive Spiralectrode® emitting electrodes are fixed top and bottom to the emitting frame. Self-tensioned and permanently aligned, they present areas of maximum emission per unit of power input. Top emission can be maintained with maximum applied voltage, because Spiralectrodes eliminate misalignment.

8. Minimum maintenance—The common maintenance headache in most precipitators is frequent replacement of emitting electrodes. Because of rugged suspension and patented electrode design, Buell's 10-year replacement record in this critical area is under 2%.

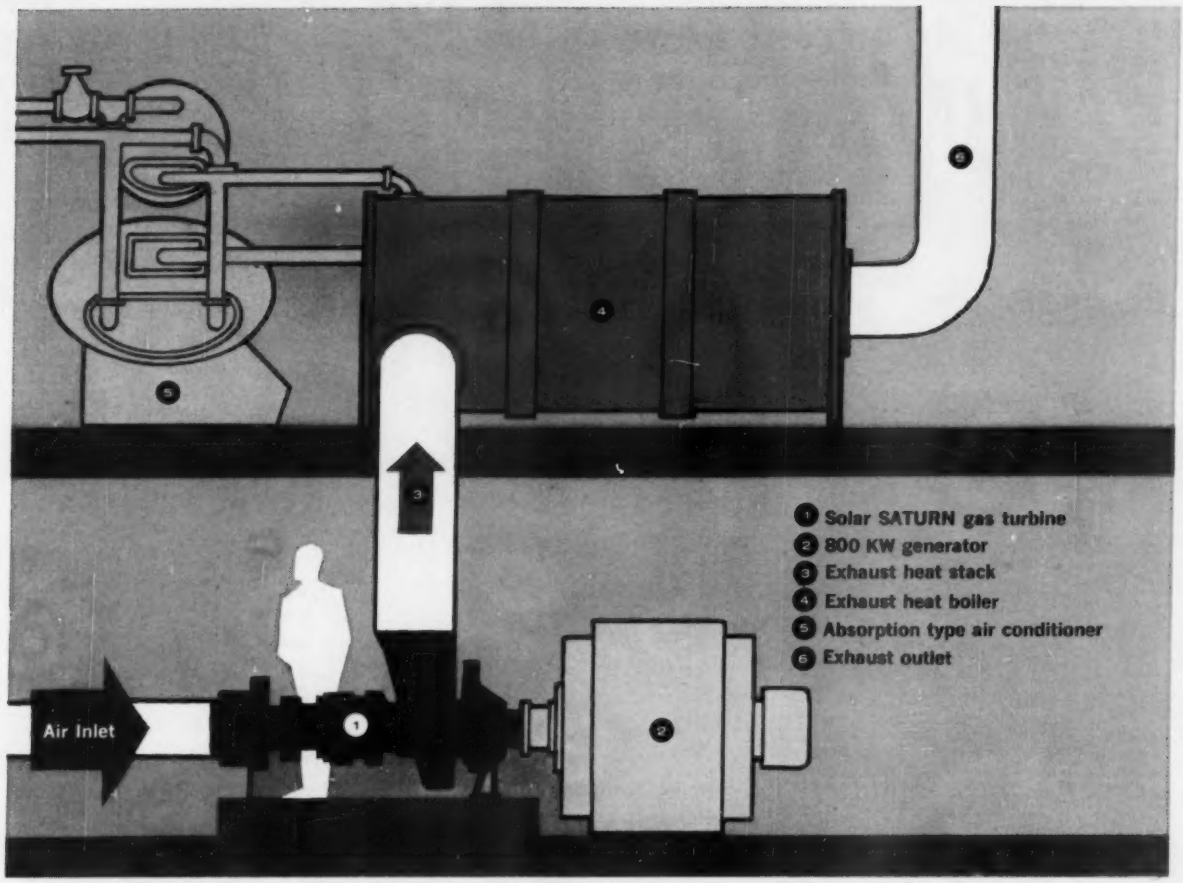
RAPPING

9. Effective rapping—avoids reentrainment—Buell mechanically raps one row of electrodes at a time, in a continuous cycle. Special pockets in collecting electrodes, and section-by-section rapping in the direction of gas flow, ensure against reentrainment.

You're sure to be pleased with the superior performance and minimum maintenance you'll get with a Buell SF Precipitator! Buell Engineering Co., Inc., Dept. 52-J, 123 William St., New York 38, N. Y. electric precipitators · cyclones · bag collectors · combination systems · classifiers. **Member Industrial Gas Cleaning Institute**

buell Norblo

For more data circle 527 on Post Card



Solar gas turbine exhaust heat multiplies thermal efficiency

This unique system of efficient exhaust energy utilization illustrates one of the many advantages of Solar gas turbines. In addition to the turbine's main shaft power, exhaust gases can be put to work to multiply the thermal efficiency of the installation up to three times that of the prime mover alone.

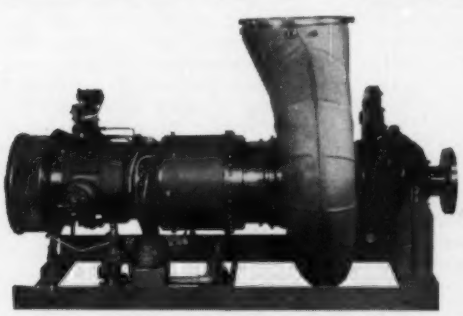
In the typical system illustrated above, Solar *Saturn* gas turbines turn 800 kw generators, providing electricity for lighting and machinery. Turbine exhaust heat is passed through a boiler to provide steam for process or building heat and absorption air conditioning.

This installation with three *Saturn* engines produces 2400 kw of electrical energy and 16,150 lbs of steam per hour. The complete package fits in a 60 ft by 40 ft space. The turbines will run on gasoline, kerosene, diesel fuel and natural or manufactured gas.

Exhaust heat utilization systems are easily adaptable to any job where electric power generation is needed, such as manufacturing and processing plants.

Solar gas turbines with their light weight, compactness, lack of vibration, long life and instant start capabilities are ideally suited for such jobs as electrical power generation, pumping, field and pipeline compression, oil well servicing, vehicle or marine propulsion.

Solar's family of gas turbines, from 50 to 1100 hp, are designed specifically for industrial use. Their design and manufacture are the result of over 15 years of experience. For further information, write to Dept. J-148, Solar Aircraft Company, San Diego 12, California.



SOLAR

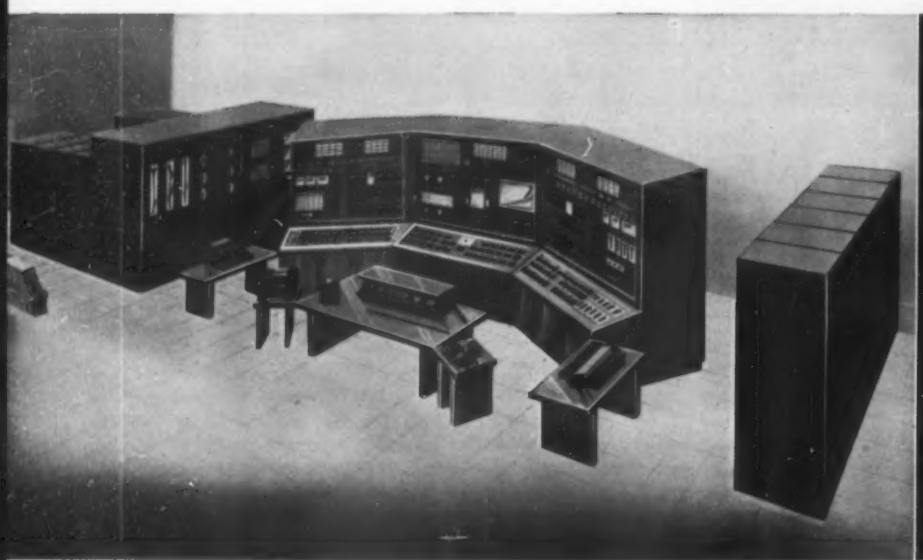
A subsidiary of International Harvester Company

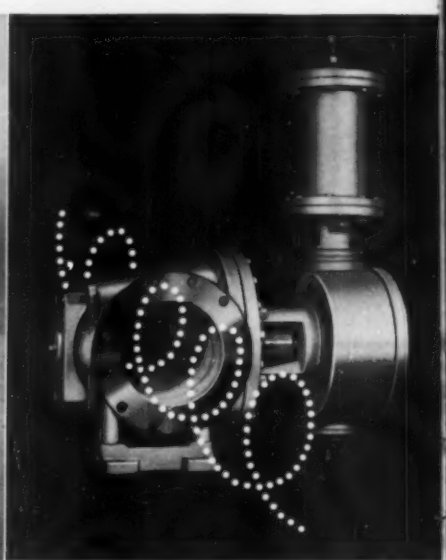
For more data circle 528 on Post Card

Current news reports

WHAT'S HAPPENING IN POWER SERVICES?

Highlights: A high voltage control center that requires half as much floor space. Smaller power transformers with considerably more kva capacity. These examples demonstrate the extra value that is standard with Allis-Chalmers . . . the greater efficiency and the added productivity that are yours when you buy A-C products, systems and services. Call your nearby Allis-Chalmers office for details or write Allis-Chalmers, Industries Group, Milwaukee 1, Wisconsin.

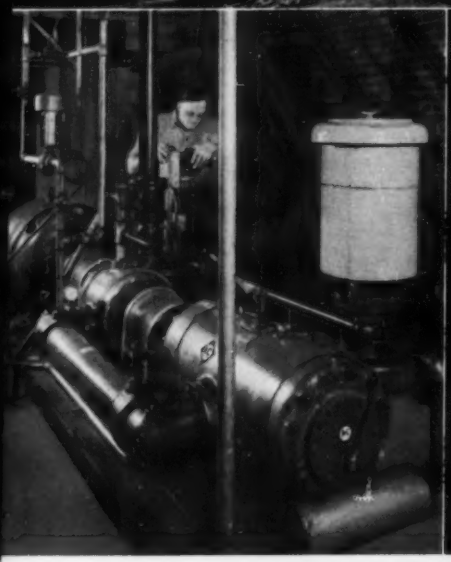


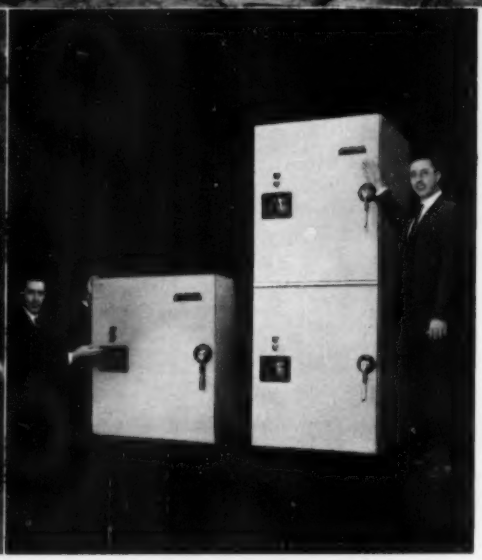


For quality control . . . lower power costs: With the acquisition of Consolidated Systems Corporation last year, Allis-Chalmers extended its ability in the areas of data gathering, handling and utilization. CSC provides such experience acquired from more than 500 successful system projects. Recently, Allis-Chalmers, Consolidated Systems and International Business Machines Corporation effected a nonexclusive mutual agreement relating to the production and marketing of automated control systems.

For the typical system, A-C takes functional responsibility for the system using IBM data processing computer equipment, CSC specially engineered data conditioning equipment, instrumentation, and A-C power and industrial processing equipment. Now, Allis-Chalmers brings balance of specialized judgments to bear on your problems . . . drawn on significant experience . . . to make major "contributions to the art" in many phases of *Systemation* and help you be sure before you invest.

"Open road" for unrestricted flow: This *Rotovalve*, when wide open, offers no greater resistance to flow than a straight pipe of equivalent length. Promotes lower pumping costs. Actually seats itself tighter with use. And special shutoff characteristics reduce water hammer. All moving parts are totally enclosed, yet easily accessible.





Transformers "grow up" but don't get bigger: New Allis-Chalmers transformers deliver as much as a 30% increase in kva without any increase in size or weight. This permits replacement of old transformers without altering base mountings or overhead structures. This unit being installed has twice the rating of the neighboring 3500-kva transformer.

More air . . . less wear, with vibration-free compressors: *Ro-Flo* compressors with sliding-vane rotary design eliminate operating losses inherent in reciprocating machines. Centrifugal force keeps vanes in close contact with cylinder walls, automatically compensating for wear. In addition, fewer moving parts result in less wear, reduced maintenance costs.

So low, two fit where one used to go: This new *SpaceMaker* control center is the first completely new 2- to 5-kv motor controller development in more than a decade. New, compact two-high design can cut floor space requirements in half. Complete drawout construction makes it the safest, most easily accessible controller on the market. New flame-retardent, track-resistant Super *Pyro-Shield* insulation adds to reliability, reduces size and weight.

A-1522

SpaceMaker, Pyro-Shield, Ro-Flo and Rotovalve are Allis-Chalmers trademarks. *Systemation* is an Allis-Chalmers servicemark.

ALLIS-CHALMERS

For more data circle 529 on Post Card

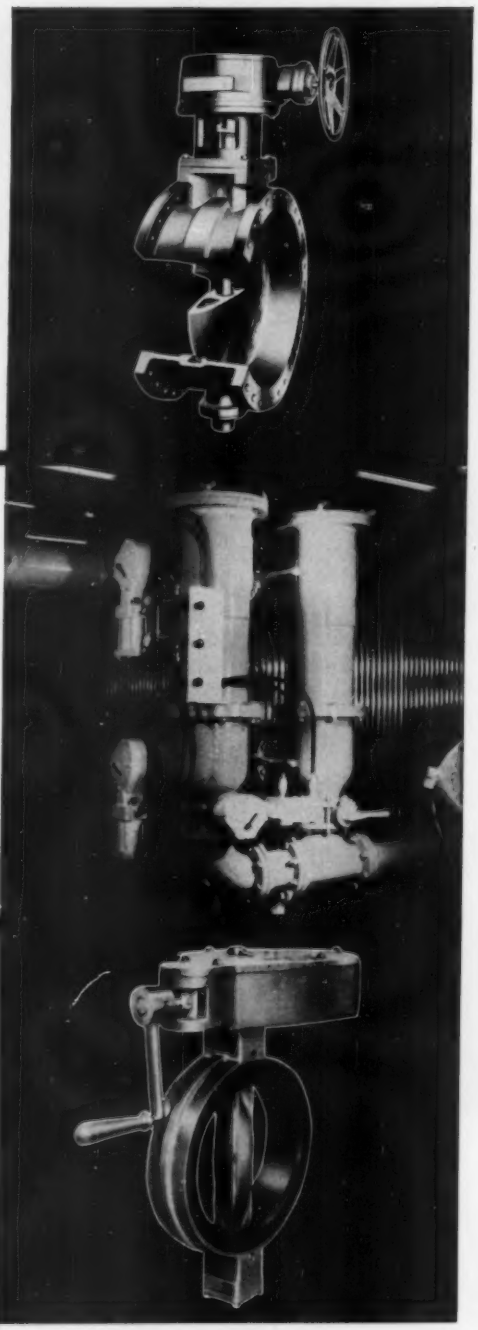
PRATT POWER PLANT PRODUCTS are all NEW for the '60's

NEW Rubber Seat Butterfly Valves

The time-proven Henry Pratt features are now augmented by such new design features as: ADJUSTABLE SEAT that can be tightened, or even replaced without removing shaft or disc. LOWER SEATING TORQUES, lowers actuator cost and provides remarkable ease of operation. Longer operating life through accurate control of disc-seat interference, giving tightness, without wear.

The new Pratt Butterfly Valves are available in sizes 3" through 144" and for pressures to 150# in both wide and narrow face-to-face. Also furnished with integral expansion joint.

Write for complete information.



NEW PRATT CYCLONE STRAINER

The new Pratt Cyclone Strainer eliminates the manual cleaning usually associated with this type of equipment. Backwashing operations are completely automatic and can be accomplished in seconds.

Unique design simplifies piping and installs for *far* less than ordinary designs.

Patented "Cyclone" action keeps larger particles away from basket—keeps strainer "on the line" longer.

Features rubber seat butterfly valves for longer life and positive action. Manual or automatic valve operators.

Write for Bulletin S-1-G

NEW Monoflange Mark -II

No valve is easier to install or operate. The Monoflange fits between existing pipe flanges—no gasket is necessary. With completely tight shut-off at 150# psi, the Monoflange Mark II finds many applications where economy is paramount, but long life is necessary.

New "Sidewinder" manual operators are available for standard or buried service with crank, handwheel or chainwheel. Cylinder, Diaphragm topworks or electric motor operators also available.

Write for Bulletin D-10-G.

HENRY PRATT® Creative Engineering for Fluid Systems

HENRY PRATT COMPANY
319 W. Van Buren Street, Chicago 7, Illinois
Representatives in Principal Cities

For more data circle 530 on Post Card

Power plant stretches diesel service -cuts maintenance costs- with AMERICAN D&G Oil No. 53

By C. F. KLENNER Carl Klenner is a specialist at helping customers with their lubrication problems. A graduate of the Michigan College of Mining and Technology, he has been serving commercial customers since 1948. He also attended the Company's Sales Engineering School.

★ ★ ★

At Roseau, Minnesota, the Municipal Power Plant uses Fairbanks Morse Diesel Engines for the generation of the city's electricity. And since 1946, lubricating oils supplied by our Company have played an important part in the excellent maintenance of this plant.

For example, diesel unit number two was overhauled in 1954 after six years' service. At our recommendation, AMERICAN D&G Oil No. 53 was put in the crankcase at that time. After 19,000 hours of oil service, the unit was taken down again. All rings were free, bearings and rings showed minimum wear, and there was negligible carbon on the piston skirts. With AMERICAN D&G Oil, this unit has averaged 4,584 horsepower-hours per gallon of oil.

For additional information about AMERICAN D&G Oil, contact your nearby American Oil Office.

American's C. F. Klenner checks performance reports with power plant superintendent Carl Grand.

Quick facts about
AMERICAN D&G Oil

- Made from highest quality solvent-refined stock.
- Contains additives which impart superior detergent-dispersant and anti-corrosion properties.
- Anti-foaming.
- Oxidation resistant.
- Recommended for
  —use with economy fuels.
  —extreme load service.
  —low temperature service.

AMERICAN OIL COMPANY
910 S. Michigan Ave., Chicago 80, Ill.

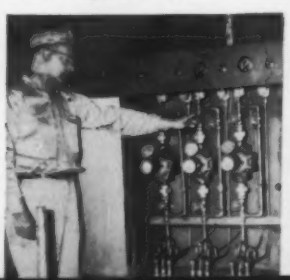
AMERICAN

ANOTHER

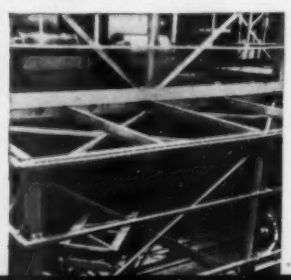
EASTERN CLEANING PLANT NEARS COMPLETION

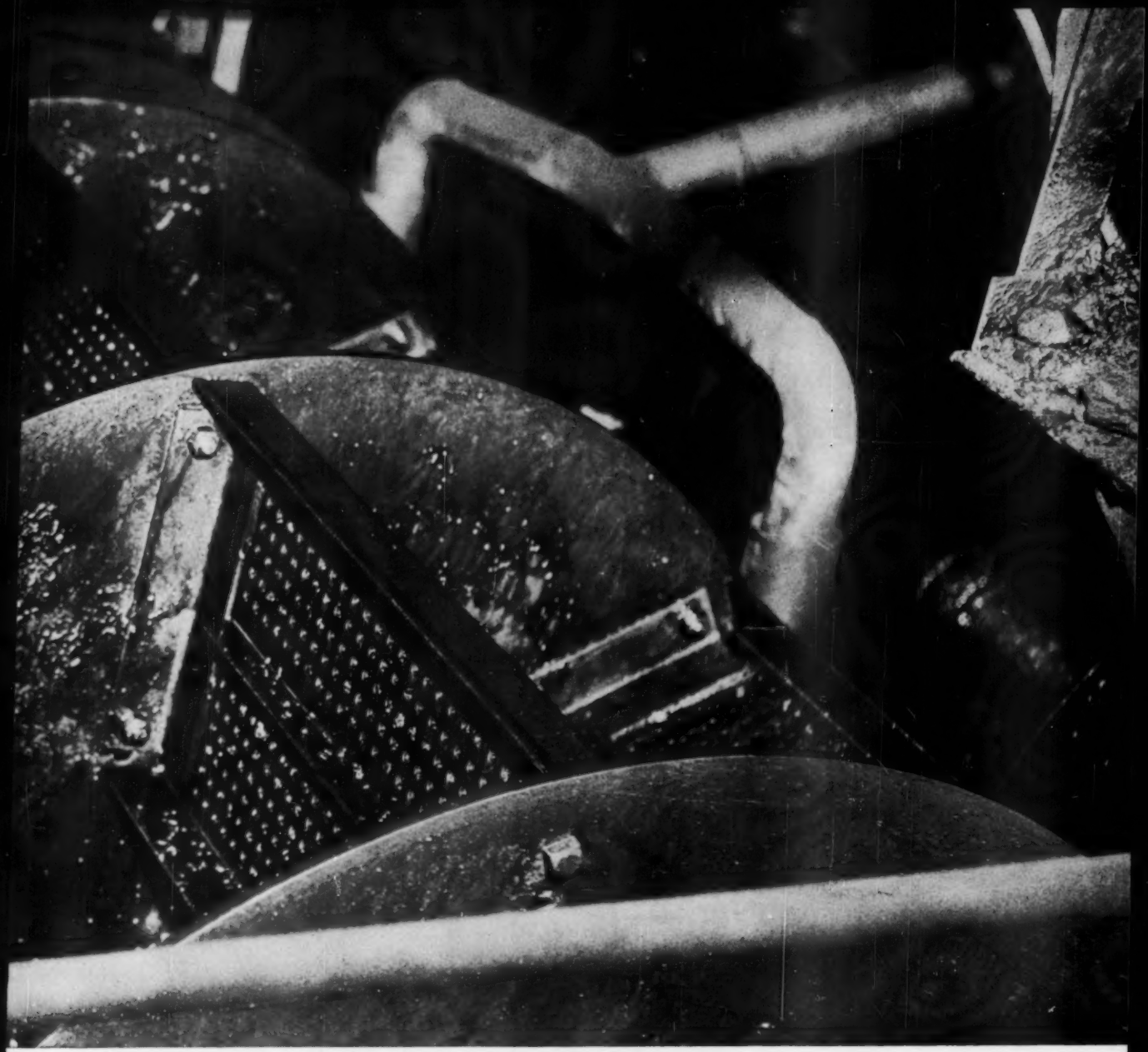
This centrifugal dryer is one of the methods used at Keystone to control moisture.

Maintenance foreman adjusts control panel of the automatic oil treating machine.



Magnetite is thickened here before being returned to the heavy media washer.





Heavy media washer cleans the coarse coal—effectively reduces ash.

The expansion of the coal-cleaning plant at Eastern Gas and Fuel Associates' Keystone mine located in McDowell County, West Virginia, has reached the point where much of the new equipment is already in test operation.

The additional facilities at Keystone will include heavy media washers, a heavy media cyclone, froth flotation cells with their associated filtering equipment, and low-head drain and rinse screens, with centrifugal drying facilities. These additions permit Keystone to provide the best low volatile coals available today.

Designed by Eastern's own engineering staff, the Keystone plant is the second in a series of new or modernized coal cleaning plants now under construction. Another similar project is in the planning stage.

These plants are evidence of Eastern's determination to continually improve their product and their service to customers. Call any Eastern Representative for information on the wide variety of Eastern coals.

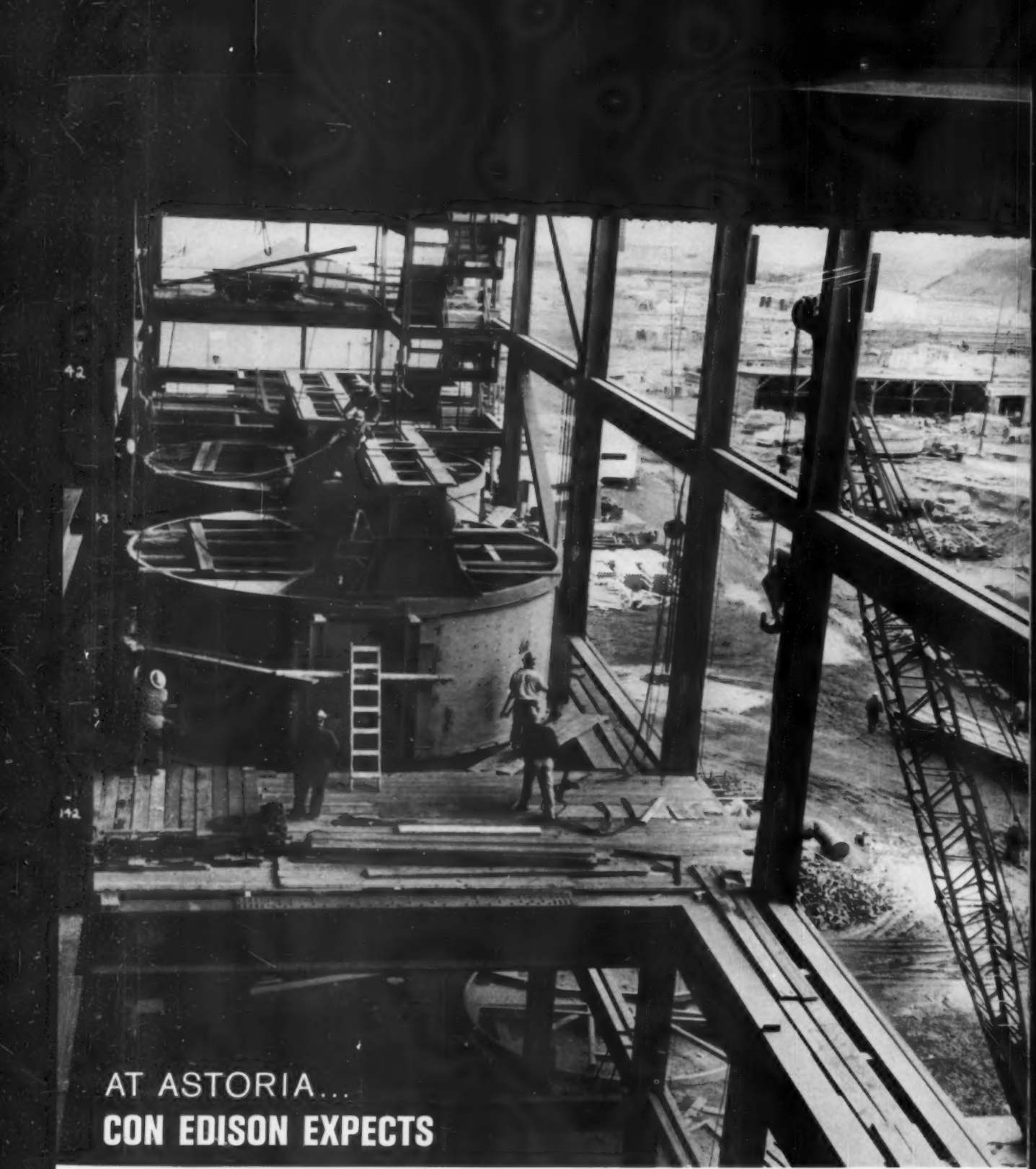
Eastern Coals and Eastern Customer Service can help you conserve your fuel dollars.

EASTERN GAS AND FUEL ASSOCIATES

BOSTON • BUFFALO • CINCINNATI • CLEVELAND • DETROIT • NEW YORK
NORFOLK • PHILADELPHIA • PITTSBURGH • SYRACUSE

EASTERN GAS AND FUEL ASSOCIATES — BEACON COAL

For more data circle 532 on Post Card



AT ASTORIA...

CON EDISON EXPECTS

FUEL SAVINGS OF 8% FROM FOUR NEW LJUNGSTROMS®

Four new Ljungstrom Air Preheaters are being installed by Consolidated Edison Company of New York, Inc., on their Astoria Stations' #50 boiler unit. With a total heating surface of about 547,000 sq. ft., these four units are designed to reduce the stack temperature 345° F. By transferring this heat to the incoming combustion air, a fuel savings of about 8% is realized. Addition of these units makes a total of 16 Ljungstroms installed at Astoria . . . 77 either installed or on order in the entire Con Edison system.

Our engineers will be glad to recommend ways to improve your operating results on new or existing fuel fired units. For information, please write to:

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N.Y.

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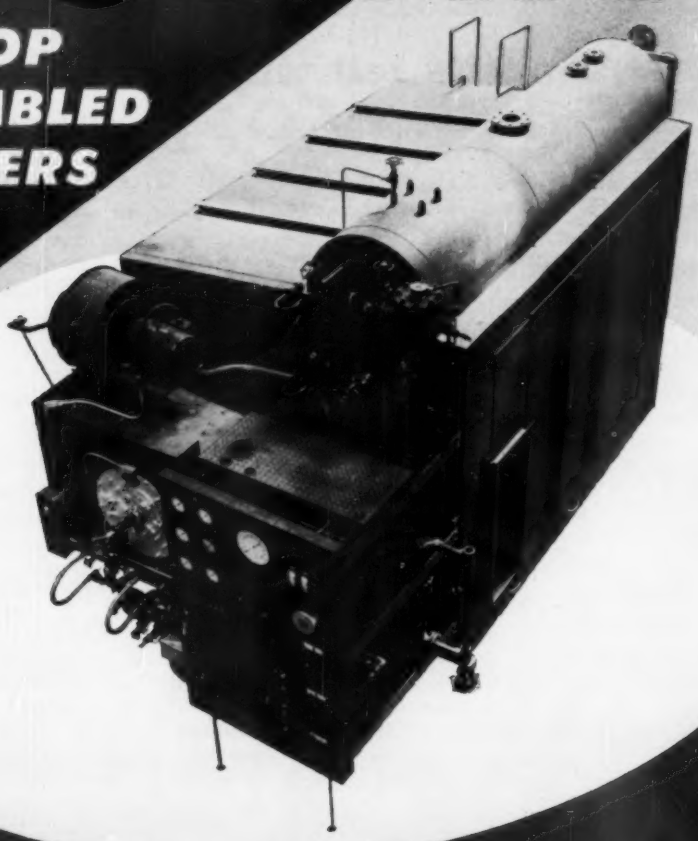
IN THE SPOTLIGHT

MURRAY

SHOP ASSEMBLED BOILERS



Wide acceptance of MURRAY Shop Assembled Boilers is indicated by their nationwide use. Repeat orders further indicate their acceptance by satisfied customers who have recognized the many added features which are STANDARD with MURRAY.

A typical MURRAY Shop Assembled Steam Generator is in the spotlight above showing one of many burner and control arrangements available for units producing 5,000 to 100,000 lbs. of steam per hour.

MURRAY IRON WORKS CO., BURLINGTON, IOWA

Murray Boilers Stand the Test of Time

For more data circle 534 on Post Card

YARWAY news briefs

from **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD

YARWAY GUN-PAKT EXPANSION JOINTS ARE BEING SPECIFIED IN RECORD NUMBERS

These user-benefits tell why:

All over the country a rapidly-increasing number of expansion joint jobs on steam and high temperature water piping at utilities, industrial plants and institutions are being specified "YARWAY GUN-PAKT." Here's why:

TROUBLE-FREE SERVICE
Shutdowns are eliminated. Packing can be added *under full line pressure.* No vents. Joints never need repacking.

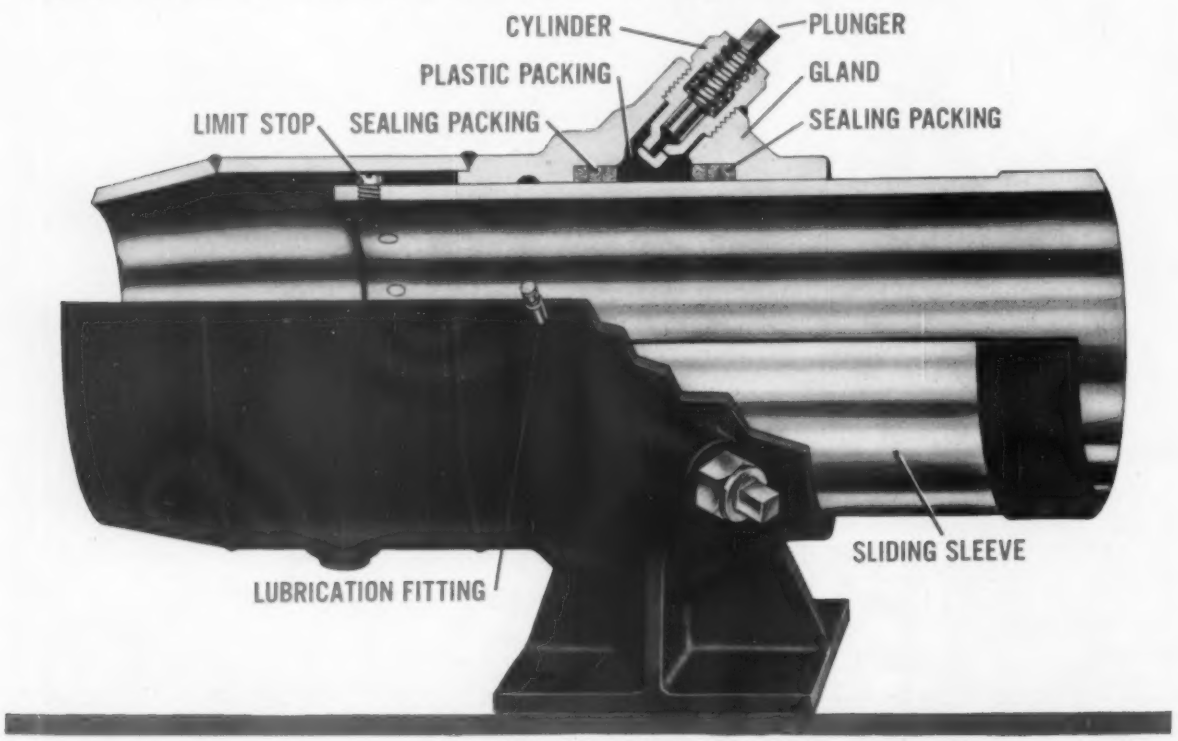
SIMPLIFIED DESIGN
Sectioned view (below) shows at a glance the simple, compact design. Provides easy accessibility, takes less space to install and maintain, needs smaller manholes, fewer joints per length of pipeline.

RUGGED DEPENDABILITY
All-steel construction, with durable, chromium-plated seamless steel sleeves. *No chance of metal fatigue.*

INTERNAL AND EXTERNAL GUIDES
Positive alignment of sleeve in stuffing box, *where it counts.*

MINIMUM MAINTENANCE
Never a shutdown for repacking—and records show an average of one manhour and 65 cents worth of packing added per joint per year. *Many Gun-Pakt Joints have been in service over 25 years with only this nominal maintenance.*

Why don't *you* investigate Yarway Gun-Pakt Joints by calling a Yarway Sales Engineer at one of the 20 Yarway offices located from coast-to-coast—or simply by writing for Bulletin EJ-1917.



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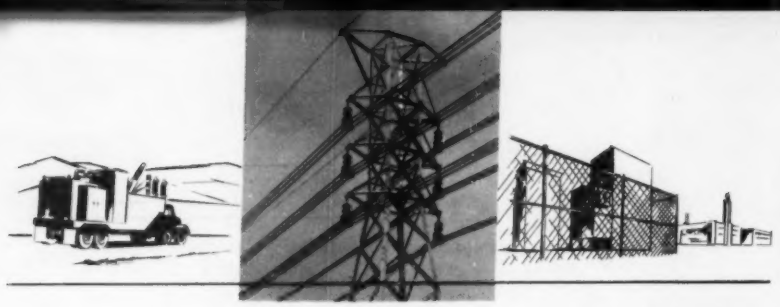


CHANGING SHAPES IN T & D

KEEPING PACE with our exploding national growth—both in economy and population—will call for one commodity (if nothing else)—ELECTRIC POWER. All authorities agree on the prediction that our generating capacity will *double* by 1970, and *quadruple* by 1980.

With this increase in generation will come a corresponding increase in all the facilities required for transmitting and distributing this energy to the users—both domestic and industrial. Population increase, alone, will create a fantastic market in electrical appliances—for domestic use. And, for the production of these products, *industry* will require a corresponding amount of electric energy.

For many years, both transmission and distribution (T and D) have followed a more-or-less stable pattern of development.

In recent years, however, both utilities and heavy industry have been forced to take a completely new look at their means for transmitting and distributing electric power. Voltages, for both categories, have increased at a rapid pace in the last 10 years. Once, industry thought of 2300 volts as the optimum in distribution potential; now, 33 and 66 kv are accepted standards in some industries.

In the transmission category, we are all familiar with the developments, from 33 and 66 kv, on up to 375 kv. Then came the breakthrough, to what we now refer to as EHV (extra-high-voltage). In recent months, we've reported "Project EHV" and "Apple Grove"; both are research and test projects—conducted jointly by manufacturers and utilities.

Transformers, switchgear, insulation, cables and other associated equipment have all undergone radical changes, also. Towers have been developed of aluminum, concrete and laminated wood designs—all a part of the "Changing Shapes" pattern. Conductor configurations have gone into standard "bundled" patterns, as a matter of sensible economics, to utilize existing structures and rights-of-way.

While the world has been dazzled by the developments in military weapons and space technology, the power field has been producing as many "miracles," but all for the betterment of mankind. Routine reporting of these developments has taken place within the pages of POWER ENGINEERING for 60 years. Once a year, we devote a special issue to the progress in one particular phase of the power field. And, when it's justified, we give a summary, or roundup, of the developments in some special category.

IN JANUARY of this year, we gave our readers a "status report" on EXOTIC POWER: this included MHD, Nuclear Power, Solar Energy, Fuel Cells, and such "unusual power sources." (These won't be *unusual* in a few years; they will be the *conventional*.)

October, 1960, gave our readers a special section on PEAKING POWER — Hydro, Gas Turbines, Diesels, and Steam Turbine sources of energy, designed for peak-shaving only.

And, in January of 1960, the entire issue of POWER ENGINEERING was devoted to AUTOMATION IN THE POWER FIELD. Computers, controls, instrumentation and "hardware" were discussed by experts in this field.

Now, due to the many exciting changes taking place in the field of energy transportation, POWER ENGINEERING presents: "Changing Shapes In Transmission and Distribution."

To offer best coverage of the field, we have sought some of the top authorities in the field to bring our readers the story of T and D today.

Power Pools
FRANCIS ADAMS
Federal Power Commission

Insulation Trends
JOHN M. SHEADEL
Ohio Brass Co.

Underground EHV
L. I. KOMIVES
Detroit Edison Co.

Distribution
R. F. LAWRENCE
Westinghouse Electric Co.

Substations
HAROLD FOSSUM
Pioneer Service & Engineering

Metering
JAMES H. PATTON
Sangamo Electric Co.

D-C Transmission
DR. COLIN ADAMSON
University of Manchester

Superconductivity
DR. RICHARD McFEE
Syracuse University

Bob McCaw
EDITOR

PRESENT STATUS OF POWER POOLS

Tremendous load growth will hasten interconnection and coordination on regional or larger scope

STATUS OF THE interconnection and coordination of power systems may be described broadly in terms of mileage of high-voltage transmission circuits, interconnections, location and size of power pools and the degree of coordination of system and pool operations. Coordination of power systems to a substantial degree cannot be achieved without adequate interconnections, but the existence of interconnections does not necessarily signify that there is coordination to a significant extent. Regardless of the degree of coordination, two or more interconnected power systems operating on an area or regional basis under contractual or informal operating arrangements constitute a power pool.

There now exists a high degree of interconnection and coordination throughout the nation. Except for a few systems, all of the principal electric utilities within the continental United States are interconnected and their facilities form parts of a national grid consisting of a common network of lines extending from the Atlantic coast to the Pacific coast and from Canada to Mexico. The Minnesota Power & Light system, now isolated from the grid, has become a member of the Upper Mississippi Valley power pool and will be connected in the near future to the Eastern Missouri Basin power group. The Rio Grande-New Mexico interconnected systems pool will soon be connected to the grid via a 220-kv connection to the Arizona interconnected systems. Interconnected systems in the state of Michigan, although not directly connected to the grid, are indirectly linked to the U.S. network at the Ontario-New York border through the facilities of the Hydro-Electric Power Commission of Ontario, Canada. Although connected to the grid by connection with systems in Texas, the Southwestern Public Service Company system in eastern New Mexico, western Texas and fringes of Oklahoma and Kansas usually is isolated from the grid.

THIS NATIONAL NETWORK of transmission lines and generating facilities is composed of six operating regional interconnected groups of various sizes, as shown on the accompanying map of the United States. Designations of regional interconnected groups or systems, subgroups, and pools included in this statement are used solely for purposes of identification, and no official status is intended where none exists today. The designations are taken from reports to the Federal Power Commission, technical publications and other miscellaneous sources, and where not available, they were coined:

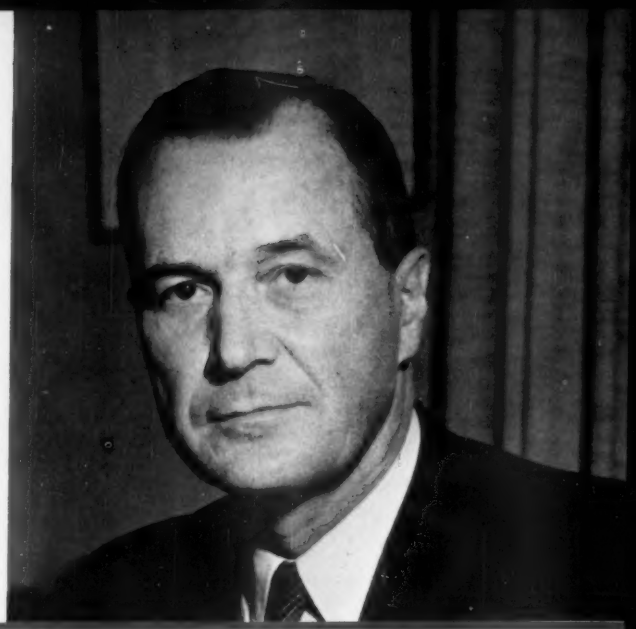
1. The Canada-United States Eastern Interconnection, composed of several formal and informal pools operating in New England, New York, Canada and Michigan.

2. The Pennsylvania-New Jersey-Maryland Interconnection, a coordinated pool operating in all or parts of Pennsylvania, New Jersey, Maryland, Delaware and the District of Columbia.

3. The Interconnected Systems Group, including formal and informal pools, operating in all or parts of 30 states in a region of about 1,400,000 square miles extending from the Canadian border

Francis L. Adams

As Chief Engineer of Federal Power Commission and Chief of the Bureau of Power, Francis L. Adams has the responsibility for surveys of power supply and requirements—throughout the U.S. He also keeps tab on interconnection and coordination of power systems, and makes analyses of hydro power projects. "Frank", as he is known by his many friends, received his engineering education at Univ. of No. Carolina and Lowell Institute. He is a member of the U.S. and Canada International Joint Commission, Chairman of U.S. Committee of World Power Conference, Chairman of U.S. Delegation to W.P.C. in Belgrade—1958, and in Madrid—1960.



southward and eastward through the Great Plains and Central States to the Atlantic Coast and Gulf of Mexico.

4. The Northwest Interconnected Systems Group operating in all or parts of Washington, Oregon, Idaho, Utah, Montana, Wyoming, Nebraska and Colorado, and in British Columbia, Canada.

5. The Pacific-Southwest Interconnected Systems Group operating in California, Nevada and Arizona.

6. The Texas Systems Group operating entirely in the state of Texas.

Each of the six regional groups is made up of two or more subregional groups as follows:

Canada-United States Eastern Interconnection includes three subgroups in the United States; i.e., the New England Operating Group, the State of New York Operating Group and the State of Michigan Group. In turn, the New England Operating Group consists of the Boston War Materials Center Pool, Connecticut Power Pool, the Connecticut Valley Power Exchange, Eastern Utilities Associates and other individual power systems. The State of New York Operating Group is made up of the Upstate New York Interconnected Systems pool and the Southeast New York State Companies pool. The State of Michigan Group is made up of four operating power systems. The Canadian portion of this interconnection is composed of the Hydro-Electric Power Commission of Ontario and other connected systems in Canada.

Pennsylvania-New Jersey-Maryland Interconnection, a highly coordinated regional power pool, is composed of Public Service Electric and Gas Company, Philadelphia Electric Company, Pennsylvania Power & Light Company, Delaware Power & Light Company, Luzerne Electric Division-U.G.I. Co., Atlantic City Electric Company, Metropolitan Edison Company, New Jersey Power & Light Company, Jersey Central Power & Light Company, Pennsylvania Electric Company, Baltimore Gas and Electric Company, Potomac Electric Power Company, Hershey Chocolate Corporation, and Bethlehem Steel Company- Sparrows Point Plant.

Interconnected Systems Group is very extensive and composed of the North Central Area Group, the Southeastern Interconnected Systems, the Southwest Power Pool, the Illinois-Missouri Pool, the Wisconsin-Illinois Systems, the Eastern Missouri Basin Group, plus other individual connected power systems not part of a power pool.

North Central Area Group operates in Indiana, Ohio, West Virginia and portions of Maryland, Michigan, Pennsylvania, Virginia, Kentucky, and Tennessee and includes American Electric Power System, an integrated pool; Allegheny Power System, an integrated pool; the Ohio Edison-Pennsylvania Power integrated pool; and other electric systems, some of which are members of informal pools.

Southeastern Interconnected Systems operate in North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee and portions of Virginia, Kentucky and Mississippi. This group includes the Tennessee Valley Authority - Aluminum Company of America coordinated pool, the Southern Company integrated pool and a number of relatively large individual power systems.

Southwest Power Pool operates in all or parts of the states of Louisiana, Mississippi, Arkansas, Missouri, Texas, Oklahoma, Kansas and Nebraska and includes the Middle South Utilities integrated power pool. The Illinois-Missouri Pool is composed of three power systems operating in Illinois and Missouri. The Wisconsin-Illinois Systems include the recently formed power pool in Wisconsin plus systems in Illinois.

Eastern Missouri Basin Group operates in all or parts of North Dakota, South Dakota, Minnesota, Iowa, Montana, Nebraska, and Wyoming and includes the Iowa Power Pool, some of the member systems of the newly formed but not yet operating Upper Mississippi Valley power pool, plus other individual power systems now in the process of organizing formal power pools.

Northwest Interconnected Systems Group includes the Northwest Power Pool, the Colorado - Wyoming Interconnected Systems and individual connected power systems. The Northwest Power Pool operates in all or parts of the states of Washington, Oregon, Idaho, Utah, Montana and in British Columbia, Canada. It is subdivided into two units

designated the East Group and the West Group. The East Group is formed by the Montana Power Company and the Utah-Idaho Interconnected System, a pool consisting of Utah Power & Light Company, Idaho Power Company and Telluride Power Company. The West Group is composed of the Intercompany Pool (The Washington Water Power Company, Pacific Power & Light Company, Portland General Electric Company, and Puget Sound Power & Light Company) plus the Bonneville Power Administration, City of Seattle, City of Tacoma, other connected public systems, and the British Columbia Electric Company in Canada.

Colorado-Wyoming Interconnected Systems, sometimes called the Rocky Mountain pool, include the Bureau of Reclamation-Pacific Power & Light-Cheyenne pool, plus other individual power systems.

Pacific-Southwest Interconnected Systems Group is subdivided into three units designated as the Northern California-Northern Nevada Interconnected Systems, the Southern California-Southern Nevada Interconnected Systems, and the Arizona Interconnected Systems. The Arizona group will soon be connected to the New Mexico and the Utah-Idaho pools by lines now under construction or planned; and studies are now being made of the feasibility of connecting the Northern California - Northern Nevada systems with the Northwest Power Pool.

Texas Systems Group is composed of the North Texas Interconnected Systems and the South Texas Interconnected Systems. The North Texas Interconnected Systems include not only the North Texas Interconnected System pool composed of Texas Power & Light Company, Dallas Power & Light Company and Texas Electric Service Company, but also West Texas Utilities Company, Brazos Electric Power Cooperative, Inc., and Brazos River Authority. The South Texas Interconnected Systems include Houston Lighting & Power Company, Central Power and Light Company, San Antonio City Public Service Board, Austin Water Light and Power Department, Lower Colorado River Authority and Guadalupe - Blanco River Authority.

Size of each of the six regional interconnected groups may be indicated by preliminary data on their annual peak loads for the year 1960, given in the tabulation shown on the facing page.

These six regional groups supply more than 90 per cent of the combined peak loads of the power systems of the United States.

Development and growth of high-voltage transmission systems and power pools in the United States has progressed hand-in-hand with the rapid growth of system loads and the increasing need for transmission of larger blocks of power over longer distances. The rate of growth of high-voltage lines during the past 30 years is shown in the tabulation on page 56.

Figures for total circuit miles of overhead line of 22,000 volts and above in service by the end of the years 1929, 1939, 1949 and 1959 show the great strides made in the development of high-voltage transmission lines, particularly in the past ten years. During the ten-year period 1929-1939, nearly 34,000 circuit miles of additional overhead lines were placed in service. In the next ten years, 46,000 miles were added and in the 1949-1959 period, 102,000 miles of new lines were installed. One of the striking features during the 1949-1959 decade was the placing in service of 11,415 miles of 220,000-240,000-volt line and 2065 circuit miles of 330,000-345,000-volt line.

LARGE SAVINGS in system operating costs are not brought about by power system interconnections of themselves where their principal use is for emergency purposes only. Significant savings are only realized through coordination of two or more well interconnected power systems. Coordination may be of various degrees for economic and other reasons. Most of the interconnection and coordination of power systems in the United States takes place through formal or informal power pools. In the formal pools, contractual arrangements set forth the extent and type of coordinated operations that are contemplated. In the informal pools, the managements and the operating staffs agree from time to time on the degree of coordinated operation of their power systems to meet a desired objective.

Degree of coordination by the various pools in the United States varies considerably. Some pools provide for exchange of energy, mutual protection at times of emergency and coordinated scheduling of generating units for maintenance. Others include the foregoing plus common or coordinated load dispatching and sharing in the output of new generating capacity additions, usually on a short term basis. Some pools are coordinated on a one-system basis and provide for joint planning of generating capacity and transmission facilities in addition to all of the previously stated purposes.

Interconnection and coordination of power systems began on a two-system basis, the main objectives being exchange of energy and emergency reserves. This step was expanded to include one or more additional power systems and joint maintenance of generating units. Next came the extension of operations to an area basis with the addition of joint dispatching. Then followed combined operations on a sub-regional basis, on which rapid progress is now being made in all parts of the country.

Several factors indicate the desirability of coordination on a regional basis. The maximum size generating unit that can be justified economically is either one which can be fully loaded in two or three years or is equal to about 10 to 12 per cent of the maximum load to be served, whichever is limiting. Also, another consideration known as the "insurance factor" is coming into prominence.

It has been customary in making provisions for system generating reserves to assume that outages of generating capacity take place on a single-generator basis. The record reveals, however, that it is not uncommon to have an unscheduled outage of an entire generating station. Experience has shown that a regional power system provides "insurance" protection for such an eventuality because of the magnitude of the total available spinning reserve.

TREMENDOUS LOAD GROWTH is in prospect during the next 20 years. This is an additional important factor which will be instrumental in hastening interconnection and coordination of power systems on a regional and possibly larger basis. The limited availability of suitable power sites for steam-electric stations, increasing costs for transportation of boiler fuels, remote locations for nuclear power stations and increasing difficulties in acquiring

INTERCONNECTED SYSTEM GROUPS AND POWER POOLS IN THE UNITED STATES 1960
WASH.
MONT.
N. DAK.
MINN.
OREG.
Northwest Power Pool
IDAHO
WYO.
S. DAK.
Eastern Missouri Basin Group
Minn. P&L System
WIS.
MICH.
Wisconsin-Illinois Systems
State of Michigan Group
New York Operating Group
New England Operating Group
Connecticut Power Pool
Connecticut Valley Power Exchange
NEV.
Northern California Northern Nevada Interconnected Systems
CAL.
UTAH
NEB.
Colorado-Wyoming Interconnected Systems
COLO.
IOWA
Iowa Power Pool
ILL.
IND.
OHIO
Illinois-Missouri Pool
North Central Area Group
W.VA.
KY.
KAN.
Southwest Power Pool
Southern California Southern Nevada Interconnected Systems
ARIZ.
Arizona Interconnected Systems
N.MEX.
Rio Grande-New Mexico Pool
OKLA.
Southwestern P. S. Co. System
TEXAS
ARK.
TENN.
TVA-Alcoa Pool
N.C.
S.C.
Eastern Interconnected Group
MISS.
Middle South Utilities Power Pool
LA.
Pool
ALA.
GA.
Southeastern
Southern Company Power Pool
FLA.
North Texas Interconnected Systems
South Texas Interconnected Systems
Annual Noncoincident Peak Load-Mw
Interconnected Group or Pool
1960
Canada-United States Eastern Interconnection (U.S. Portion only) 20,700
Pennsylvania-New Jersey-Maryland Interconnection 12,100
Interconnected Systems Group 69,200
Northwest Interconnected Systems Group 11,300
Pacific-Southwest Interconnected Systems Group 13,300
Texas Systems Group 6,500

suitable rights-of-way for transmission lines indicate that use of the largest available generating units and concentration of large amounts of capacity in a single area, with development of extra-high-voltage transmission networks for regional coordination, is inevitable. The necessary large investments would require standardization and uniformity of system design on a regional and even more extensive basis to obtain the greatest benefits. This could be accomplished through joint planning of generating capacity and transmission additions and coordination of system operations.

Present status of interconnection and coordination of power systems in the United States indicates that the economic advantage of coordination of operations on a regional basis is widely recognized by the power industry, and further improvements are now in progress. For example, the 345,000-volt lines and facilities under construction in the State of New York will provide means for realizing the benefits of coordinating to a greater extent the Upstate New York Interconnected Systems pool and the Southeast New York State Companies pool.

The recently announced 345,000 to 500,000-volt grid for the Southwest Power Pool will permit fuller coordination on a regional basis to provide greater dependability of service, additional flexibility in the installation of even larger generating units, and more extensive exchange of energy, capacity and reserves. Studies of similar developments for coordinated operations are being made in the Pacific Coast area, the Southeast, and other areas.

PRESENT INDICATIONS are that the Canada-United States Eastern Interconnection and the Pennsylvania-New Jersey-Maryland Interconnection will soon be operating as one group. Also, in the not too distant future, it appears that the Northwest Interconnected Systems and the Pacific-Southwest Interconnected Systems will be operating as one group. It is too early to suggest the time when all of the major power systems in the continental United States may be operated as members of a single national system.

Western European countries have made substantial progress in interconnecting their power systems to form one large international network. The "Union for the Coordination of Production and Transport" formed by the Western European countries reports a significant advance in the field of power-frequency control, making possible operation in parallel of most of the electric network. As of the end of 1960, the electric power systems in the countries of Austria, Belgium, German Federated Republic, France, Luxembourg and Switzerland were interconnected continuously, forming a one-frequency block. The Netherlands system operates during a large part of the time in parallel with this group.

Preparations are now underway to provide means for operation of the interconnected systems in Italy on a continuous basis with the European network. The principal purposes of this Western European interconnection are to make it possible freely to transfer electric energy in all directions at all times and provide immediate mutual assistance in case of disturbances. During 1960, the Western European network served a maximum parallel load of about 47,000,000 kilowatts.

Completion of the interconnection between England and France by a direct-current cable across the English Channel will increase the size of the European power network. The Western European progress in interconnceted operation is indicated by a decrease from four operating regions in 1955 to one operating region in 1960.

In Sweden all of the power systems operate as a single interconnected unit, and Norway has substantially the same degree of coordination. The systems of Norway and Sweden are interconnected, and there is a tie between Sweden and Denmark.

Based on the present outlook, it appears that the extent of interconnected and coordinated operation of the systems of the Western European countries is approaching that of the United States and the same ultimate purpose is the goal; namely, an abundant supply of electric power at the lowest possible cost.

RUSSIAN POWER SYSTEM, in contrast to the many Western European power systems, is under one ownership control for planning, construction and operation. The degree of interconnection and coordination of the Russian power system cannot be stated with certainty because insufficient information is available on physical facilities, the capability and adequacy of interconnections, and the practices for coordinating the moment to moment operations of the interconnected network. It appears, however, that interconnected and coordinated operation has progressed to a higher level of technological and organizational development in the United States than in Russia. Advances in control and protective facilities, automatic loading of generating units via computer programs, and research and development of power equipment, are expected to maintain the margin of the United States power systems over the Russian power system in the years ahead.

Editor's Note: The Federal Power Commission, as a matter of policy, disclaims responsibility for material published unofficially by any of its employees. The views expressed herein are those of the author and not necessarily those of the Commission. END

Circuit Miles of Overhead Line of 20,000 Volts and Above in Service

Total Electric Utility Industry

Nominal Voltage	Total Circuit Miles of Overhead Line* In Service by the End of the Year			
	1929	1939	1949	1959
330,000 - 345,000	0	0	0	2,065
287,000 - 288,000	0	607	791	1,024
220,000 - 240,000	1,541	2,317	6,155	17,370
154,000 - 165,000	628	1,366	5,650	12,535
132,000 - 140,000	6,816	10,692	17,258	35,916
110,000 - 120,000	13,826	18,690	35,170	57,016
80,000 - 100,000	4,702	5,049	3,039	5,747
66,000 - 75,000	24,760	34,499	47,419	70,132
55,000 - 60,000	12,618	4,743	9,559	8,885
44,000 - 50,000	14,638	16,759	22,823	28,998
38,000 - 42,000	3,257	3,528	5,676	7,203
33,000 - 36,000	37,251	48,804	49,650	57,129
26,000 - 30,000	2,813	3,748	2,664	3,687
22,000 - 25,000	21,355	27,178	18,294	18,464
Total	144,205	177,980	224,148	326,371

*Based on Edison Electric Institute data. Does not include the following miles of line operated by REA cooperatives for which a breakdown by voltage classes is not available: 1959—37,500; 1949—9,600; 1939—0; and 1929—0.

John M. Sheadel

John M. Sheadel received his BSEE degree from Purdue University and became a member of the Ohio Brass High-voltage laboratory staff in 1938. From 1940 to 1955, much of his time was devoted to the development of improved insulation for extra-high-voltage transmission. After a further period of service as director of quality control, he became assistant to the chief engineer of the Barberton Division of Ohio Brass. He has been actively associated with various technical and standardization committees of NEMA, ASA, and AIEE.

EHV INSULATION IS READY FOR TOMORROW'S VOLTAGE

A discussion of critical factors which influence EHV insulator design

POWERFUL ECONOMIC incentives behind the trend to higher transmission voltages are reflected, most pointedly, in the unprecedented amount of research and development work now focusing on extra high voltage. Studies to date have discovered no foreseeable technical barriers to line voltages of 1000 kv or higher. The application of cap-and-pin suspension insulators at these voltages is entirely feasible.

By the end of 1961, there will be some 5500 miles of extra-high-voltage lines (300 kv and over) in operation in the United States and Canada—with many more miles under construction.

Several of the earliest lines have been in continuous operation at 345 kv (over 360 kv actually) since 1955 — performing satisfactorily with line insulation composed of standard 10-in. suspension insulator strings. This standard insulator unit looks like the same basic unit used for more than 50 years on conventional 69-, 115- and 138-kv transmission lines.

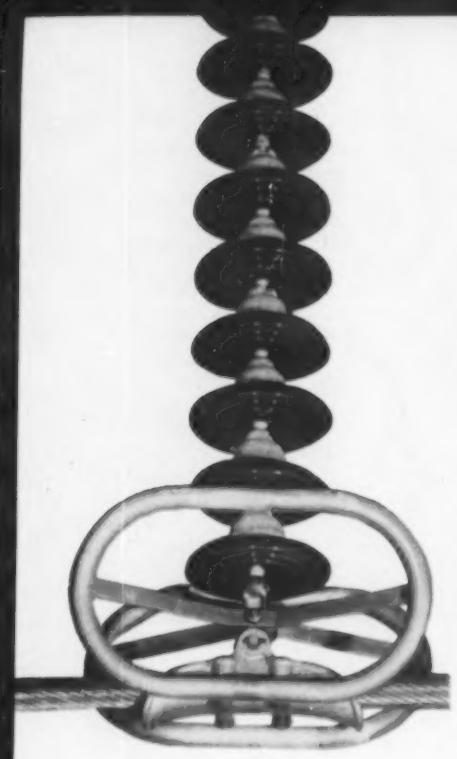
However, two important contributions which preceded the satisfactory insulation performance at higher voltages should be emphasized.

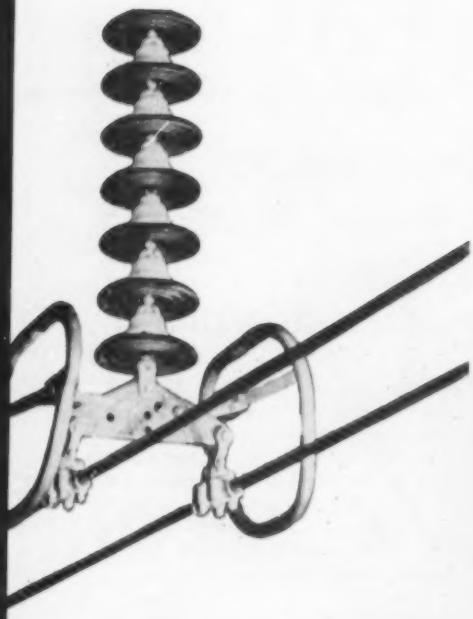
First, the standard insulator is far different from the unit of 50 years ago — or even 10 years ago. Continuous research and development in materials, processes and design have led to a remarkable change in reliability and in characteristics. Compared with the unit of 50 years ago, today's insulator has four times the mechanical strength and nearly twice the puncture strength.

Second, manufacturers and users have given a complete examination to the standard insulator in view of the insulation requirements for higher voltages. A summary of this investigation follows.

OVERVOLTAGE. On a low-voltage system, the major overvoltage hazard for line insulation is natural lightning. On 7.2-kv or 13.2-kv lines, for example, the total voltage of a direct lightning stroke may be impressed across a single pin-type insulator and cause a line flashover.

As system voltages go up, more expensive transmission line designs may be justified with ground wires





shielding the line from direct lightning strokes. Associated with the increase in voltage, suspension insulator strings also become longer and the flashover value of the insulation becomes greater. Generally, for extra-high-voltage lines lightning may be expected to cause fewer insulation flashovers.

At the same time, however, a new overvoltage problem arises in the form of heavy switching surges. Although a switching surge 2½ or 3 times normal voltage is no threat to line insulation on a 115- or 230-kv system, it is a factor to be reckoned with on a 345-, 460-kv or higher voltage system.

For these extra-high-voltage systems, switching surges of these magnitudes will impress more voltage on the line insulation than a lighting stroke to the ground wire or tower. Also, a lightning stroke may have a duration of only a few microseconds whereas the switching surge may continue for several thousand microseconds. The difference between the two types of voltages is the difference between a hammer (lightning) and a vise (switching surge).

The varieties of switching surges which may be encountered in service are fully as broad, in their own spectrum, as the varieties of lightning strokes encountered in service. Interesting phenomena have been observed, such as an unusual variation in the flashover values of insulation. Much interesting research remains to be done.

Experience and tests have demonstrated that the basic cap-and-pin-type suspension insulator is well adapted to meet the increased service requirements defined by these studies. Not only is this design the most efficient in developing full air-gap flashover strength on impulse and power frequency, but the porcelain body can be readily shaped to meet a wide variety of additional electrical requirements in the future.

CORONA AND RI. As transmission line voltages increase, the voltage stress at the line end of suspension insulator strings increases. For modern 230-kv transmission lines, standard designs of suspension insulators and line hardware are operating satisfactorily without special stress control devices. In fact, some early 230-kv transmission lines which had special stress control rings have been modernized in recent years with removal of the rings.

Above 300 kv, however, electrostatic stress becomes a more important consideration, and a great deal of research and development has centered on this problem. At these higher voltages, electrostatic overstress at the line end of the insulator string tends to produce localized corona at the insulator hardware. Thus, the design of insulators and associated hardware must be coordinated to provide the most efficient control of this stress.

Suspension clamps, yoke plates, and attachment fittings have many sharp corners and projections which may also create corona influence voltage.

While the design of both insulators and suspension hardware could be modified to improve the voltage

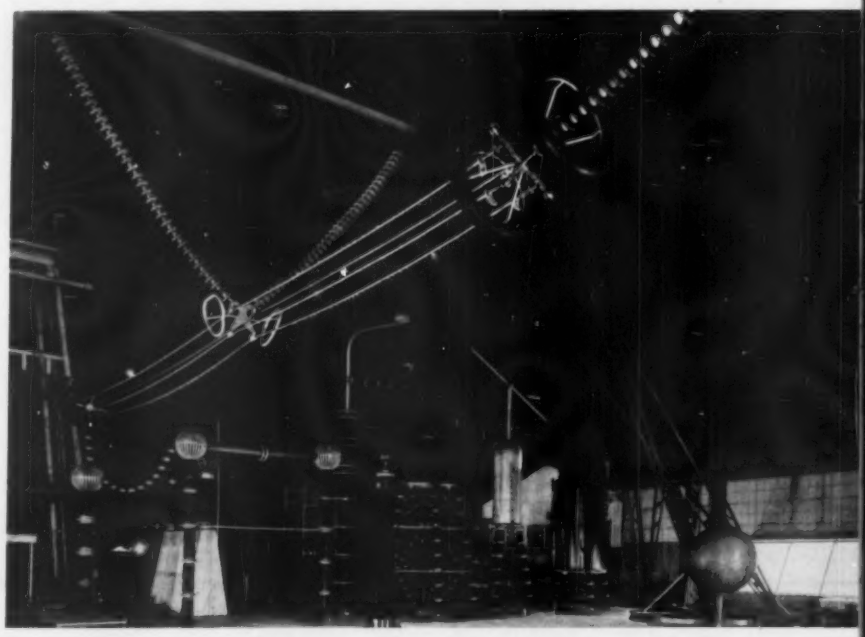


Fig. 1 (top) is a 345-kv single-conductor suspension assembly with control shields. Fig. 2 (above) is a 345-kv twin-conductor suspension assembly with control shields. At right, Fig. 3 shows suspension assembly for 775-kv experimental transmission line undergoing corona and radio influence voltage tests in the Ohio Brass Company's high-voltage outdoor laboratory

stress characteristics, the changes would be more difficult to install and maintain.

It has generally proved more practical to design control shields to surround both line-end insulators and supporting hardware with an elementary Faraday cage in the form of control rings, thus reducing the electrostatic stress within and near the shield structure.

Such assemblies have performed satisfactorily for many years on extra-high-voltage lines in many parts of the United States and Canada. Figs. 1, 2 and 3 show typical shielding structures developed for single, double and quadruple conductor bundles at voltages up to 775 kv.

Regardless of the efficiency of design, however, electrostatic field-control devices require extra phase spacing and thus have a detrimental effect on such vital factors as surge impedance, stability limits, tower size and right-of-way width.

For this reason, studies have been undertaken to determine the feasibility of eliminating control shields.

The assembly shown in Fig. 5 is corona-free, without control shields, at a voltage of 400 kv to ground—equal to a system voltage of more than 650 kv. The assembly shown in Fig. 4 is corona-free, without control shields, at 550 kv to ground—equal to a system voltage of approximately 865 kv.

Fig. 4. Four-conductor suspension assembly undergoing test. Assembly is corona-free without shields, at 550 kv to ground (at 865-kv system voltage)

This performance has been accomplished by modifying the suspension system so that the line-end insulator units and supporting hardware are enveloped in the electrostatic field of the multiple conductor bundle.

This "short coupled" system is inherently more adaptable to triple and quadruple conductor bundles (for reasons involving mechanical stability), but it can also be adapted to twin-conductor bundles.

The net results are attractive possibilities for tower and right-of-way economies, and for improved electrical performance of the transmission line.

SURFACE LEAKAGE. Air-borne pollution has become an increasingly important problem in many areas of our nation. Damp, contaminated surfaces on high-voltage insulation will permit the flow of surface leakage currents. Under conditions of fog or light rain, leakage current surges may occur which, in unfavorable circumstances, may cause flashover. Under usual service conditions and for applications at 230 kv and less, about one to 1.1 in. of leakage distance per each kv of line-to-ground voltage has proved to be satisfactory. This ratio has been followed approximately for extra-high-voltage lines. Experience has indicated that this is satisfactory for line insulation.

Porcelain insulators have the merit that they can be modified to complex shapes to add extra leakage distance should this be a requirement for future higher voltage applications.

CORROSION. Because of the increase in air-borne contamination and because of higher voltage stress, the corrosion problem for extra-high-voltage line insulation may be somewhat greater than for older, lower-voltage lines. Product design has done much to eliminate possible damage. Where strength requirements are met, the use of malleable iron, hot dip galvanized, will give generally suitable corrosion resistance.

For suspension insulator pins, higher strength material (normally medium carbon steel, hot dip galvanized) is necessary. For this part, conventional remedies to produce better corrosion resistance include the use of copper alloys or stainless steel, but recent developments in suspension insulators have produced

Fig. 5. Four-conductor suspension assembly is corona-free, without control shields, at 400 kv to ground—which is equal to a system voltage of more than 650 kv

a less expensive answer. A resilient galvanized steel sleeve around the suspension pin and assembled in the suspension insulator pinhole will intercept the corrosive attack on the steel pin shank and will give the added reliability necessary for higher voltage systems.

MECHANICAL STRENGTH. Because of the increased electrical stress and the transmission characteristics, large conductors or bundled conductors are specified for extra-high-voltage transmission lines. Because of the increased voltage, phase spacing is increased. These factors contribute to an increase in tower cost, which in turn encourages the trend, already apparent on lower voltage lines, toward longer spans, higher stringing tensions and increased mechanical loading on insulator string.

Although the mechanical strength of presently available insulators is more than adequate for these increased loads, some thought must be given to the expected higher incidence of conductor vibration.

For the ball-socket connection of suspension insulators, high amplitude conductor vibration will produce bending stresses on the pins. If these stresses are high enough, fatigue failure will occur, but fortunately for nearly all applications, vibration is virtually non-existent or is eliminated by dampers.

Worthwhile research remains to be accomplished. It has not been determined, for example, what other components may contribute. END

CHANGING SHAPES IN T & D

HAS EHV UNDERGROUND CABLE REACHED A VOLTAGE PLATEAU?

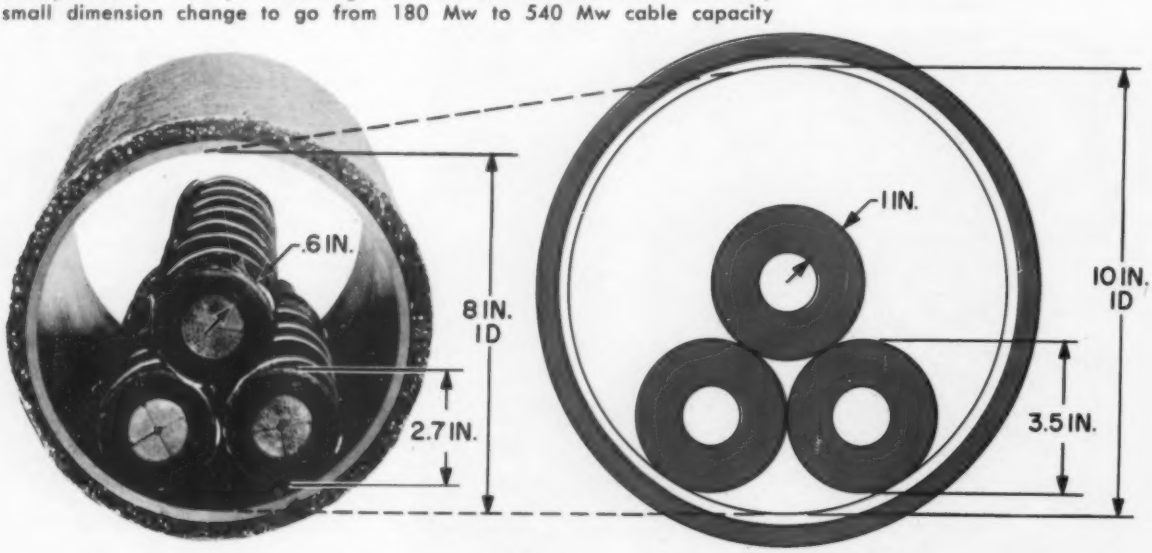
New materials, research, and engineering are key factors

RIGHT-OF-WAY NEEDS and power system design flexibility will continue to dictate the role underground cable plays in transmitting large blocks of power. While underground transmission cable voltage traditionally follows that of overhead transmission lines, more fundamental research is still needed to reach the 750-kv class.

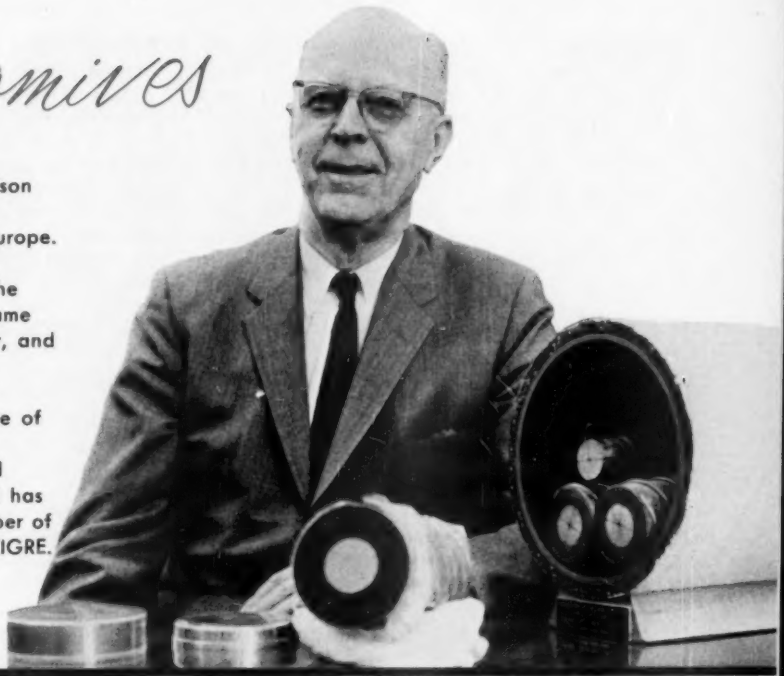
The first high-voltage lines which were built utilized underground cables to transmit electric power from a centrally located station in the larger cities to nearby load center locations. By the end of the 19th Century, when the point was reached that interconnecting of the comparatively small generating centers became necessary, overhead lines took over the task to a considerable degree. During later stages of development, underground followed overhead in a typical manner.

By 1920, large scale transmission systems developed in the United States utilizing transmission voltages ranging from 110-132 kv. Near the end of this decade, comparatively long underground cable lines were

Extrapolation of today's knowledge and use of materials shows relatively small dimension change to go from 180 Mw to 540 Mw cable capacity



L. I. Komives



Mr. Komives is the assistant general superintendent of underground lines for Detroit Edison Co. During his career he has been employed in the cable works of Siemens-Schukert in Europe. He came to the U.S. in 1924 and joined Ford Motor Co.'s engineering laboratory. In 1926 he joined Detroit Edison and subsequently became a cable engineer, high-voltage cable inspector, and superintendent of the cable division of underground lines. He attained his present position in 1953. Mr. Komives graduated with a degree of M.E. from the Technical Univ. of Budapest, Hungary. He is a Fellow of AIEE, has published a number of AIEE, EEI, and CIGRE papers, and has five patents to his credit. Presently he is a Member of Study Committee No. 2, High Voltage Cables, CIGRE.

placed in operation at these voltages in larger cities of this country. In the 1930's pioneering ventures in the higher voltage range, mostly around 230 kv, were instituted in France and again, a fairly long cable line was placed in operation at this voltage in 1936.

In the 1950's Sweden began to install 400-kv overhead lines. This time short lengths of cable were utilized as soon as the overhead lines began operating because it was found that their use allowed greater flexibility of station design. Up to now, installation of such cables over longer distances have not been made. This should be the next step if history repeats itself. Cable engineers in this country are preparing to meet this problem in time for the first commercial installation of this kind. Successful transmission of electric power by long lines of 345-400-kv underground cables is a task which is awaiting the 1960's.

For the 1970's, experiments are under way here and in Russia to develop overhead transmission lines which will operate in the 500-750 kv range. It seems that 750 kv may be the upper limit of presently available a-c transmission designs. No such underground cables are presently in the picture because of inherent limitations. Research is under way now to develop more suitable materials to correct this situation.

D-c transmission is also gaining in interest among workers in this field. The upper limits for d-c transmission seem to be higher and the capability greater at these voltages than a-c transmission.

UNDERGROUND'S ROLE. If the load doubles during the present decade, power stations with single units of 1000 Mw and plants with a total capacity of 3000 Mw may become necessities by 1970. Historically, transmission lines have matched generator units. One thousand Mw in three-phase a-c transmission lines have matched generator units. One thousand Mw in three-phase a-c transmission means 1666 amps per phase at 345 kv; 1150 amps at 500 kv and 770 amps at 750 kv. Present higher voltage transmission lines are designed to carry up to 800 amps and perhaps 1000 amps under emergency conditions. Therefore, to match generator units with transmission lines, transmission engineers have a formidable task.

Besides the problem of carrying the current, cable engineers also face the problem of keeping line losses and charging currents to a practical level at rising voltages. There is good agreement among cable engineers that presently available insulation (oil-impregnated paper) for extra-high-voltage cables reaches its practical limitations at, or slightly above, 400 kv. At 345 kv, cable lines carrying loads over 500 Mw, and under emergency conditions perhaps 700 Mw, up to distances of 15 to 20 miles are good possibilities. This premise is based on the use of cable insulation which has very low losses of the order of 0.007, resulting from power factors of 0.002 in the operating range and dielectric constant of 3.5 which is now obtainable in new oil-impregnated paper.

Synthetic materials are available which have power factors below 0.0005 and dielectric constants about 2.0, resulting in power losses of 0.001 or 1/7 of the best oil-impregnated paper insulation. However, there are no materials at the disposal of the cable engineer today which have such desirable characteristics and can also withstand the

rigors of operating under very high voltage stresses and temperatures over 100 C. In the eyes of many cable engineers it is an absolute necessity that satisfactory new insulating materials be developed without delay since, when transmission voltages of 500 to 750 kv ac are employed, underground cables will be needed which can operate at these voltages.

D-C POSSIBILITIES. When transmission of large blocks of power by dc versus ac is considered, the role played by underground cable may become greater because of economics. Assuming that economical conversion equipment is available, it seems that high-voltage cable lines having the same insulation thickness could be operated at a higher d-c voltage and could carry more electrical energy than when they are operated at ac.

As a very rough approximation, it may be said that two d-c cables of comparative size could carry the energy for which three a-c cables are needed. Most people take it for granted that the cable subjected to dc will operate more satisfactorily than under comparable a-c voltage. This may be true; however, overenthusiastic designers must be warned that so far no extra-high-voltage d-c cable of the sizes that may be necessary has been in operation for a sufficient length of time to pronounce the d-c cable superior to the a-c. A long time is needed until all the electro-osmosis effects of d-c potential on cable insulation have been proved to the satisfaction of the operating engineers. Sweden, France, and England are known to have made such experiments, and it is believed that parallel experiments are being carried out in Russia. About 10 years of successful operation of the English Channel cable should convince even the most skeptical power engineers.

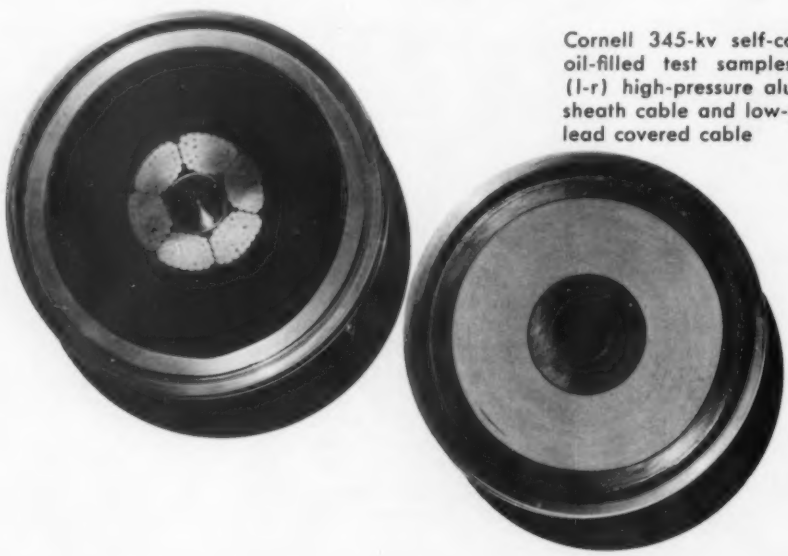
EHV CABLE TESTING. Testing, divorced from the cable manufacturer's laboratory, was started in 1935 in the Netherlands, where cables for 150-kv service were subjected to intensive tests. In 1950, testing of 230-kv cables, and later 400-kv, was started in the electrical testing laboratories in France. In 1952 a testing station was inaugurated in Great Britain to test 275-kv cables which were directly connected to a 275-kv overhead line. Finally, American utilities and cable manufacturers enlisted the help of Cornell University and started testing 345- to 400-kv cables in April 1961.

The Cornell Extra-High-Voltage Cable Field Testing Project is based on an agreement between four American cable manufacturers to undertake extensive research in their plants and to supply test samples of their designs, and the participating electric utilities to sponsor the supplementary field testing necessary to prove these designs. Field testing expense is to be borne by the users. Cornell University was selected to provide a research project in the power field for participation in by faculty and student body.

Four complete cable systems are under test at Cornell. Two systems are of the familiar pipe-type which differ in conductor construction and insulation treatment. The third system employs high-pressure, self-contained, aluminum sheath cable. The fourth cable system uses low-pressure, oil-filled, self-contained lead covered cable similar in design to the 132-kv cables which have been operating successfully in this country for over 30 years.

The Cornell test is scheduled for a three-year period. The first two years will evaluate the service aging of the 345- to 400-kv cable systems as a measure of their acceptability for power systems in this country. During this time the cables will be subjected to 345 kv (one month), 380 kv (one month) and 415 kv (twenty months). Circulating current will raise and maintain conductor temperatures either continuously or as a cyclic load corresponding to loads of 500 to 600 Mw at 345 kv.

The third year will be used to



Cornell 345-kv self-contained oil-filled test samples include (l-r) high-pressure aluminum sheath cable and low-pressure lead covered cable

explore the probable limits of these cable systems at higher voltages and conductor temperatures. Cables will be subjected to 415 kv (six months) and 450 kv (five months) and to conductor temperatures — obtained by continuous or cyclic loading — corresponding to over 600 and 700 Mw at 345 kv. Finally, during the last three months, the voltage will be raised to about 500 kv (limit of the transformers) under loading conditions comparable to those used during the first two years.

The tests so far indicate that the American cable manufacturers succeeded in making cables for 345- to 400-kv service which have fairly low initial insulation losses and which are quite rugged.

CABLE INSTALLATION. Extra-high-voltage cables were developed in Europe and installed at hydro stations, substations, etc. in such short lengths that few mechanical problems attended cable pulling. Cable jointing was not necessary and therefore was not developed. True, there were terminating problems, but these were solved by terminals with series capacitors for voltage grading. These terminals were prepared and in some cases applied to the cable length at the cable factory. American cable engineers discovered quite early that mechanical problems during installation of longer lengths of such cables multiply and become more complex. In addition, they found that design and installation problems for joints in such lines are far from having been solved.

Cables of all voltages can be installed in many different ways: directly in the soil, in conventional duct runs, or in steel pipes.

For maximum current carrying capacity, the three cables of an a-c line must be placed far enough from each other to obtain a minimum amount of mutual heating. In such an installation, care must be taken to protect the outer cover because of sheath voltages which can build up to a dangerous degree. In a conventional duct run, the three cables are closer to each other and operate in a triangular formation, thus increasing mutual heating but improving other electrical characteristics. Finally, in pipe-type cables the three conductors are quite close together, thereby reducing over-all current carrying capacity but gaining in ruggedness and the advantages of a single enclosure.

Cable engineers feel that all the methods are capable of being used for installations of cables with impregnated paper insulation up to 400 kv. At 345 kv the maximum current carrying capacity of pipe-type cables appears to be about 500 Mw. In self-contained cable installations in duct banks or direct burial, the current carrying capacity may be increased to 600 or 650 Mw. Under emergency conditions it is believed that it will be quite safe to operate these cables at values 100 Mw higher than those mentioned.

A great deal of information was gained during the last few years concerning the creation of desirable thermal conditions in the soil. The cables may be surrounded by a backfill which is selected for its low thermal resistivity under any condition (wet or dry). Thus, the current carrying capacity of the cable lines can be increased by a considerable margin over those used up to a few years ago. It is a question of economics. However, thermal characteristics of the soil surrounding the cable must be duplicated for cable joints or the joints may become the bottlenecks.

At the Cornell test site, care was taken to obtain interchangeability of cable terminals. In addition, a novel (at this voltage) experiment is being performed there in using a capacitor-graded type terminal on a low-pressure cable.

OPERATION. In studying the operation of extra-high-voltage underground cable lines as contrasted to operating lower voltage cables, surge protection, fault location, and complication due to maintaining oil pressures, among other aspects, have been given some consideration.

Fault location in extra-high-voltage cables by present methods should be satisfactory although some refinements may be needed. Power engineers may have to employ higher test voltages to surge the faulty cable. These condenser discharges are used to locate the fault by sound, and with better and more insulation, test equipment utilizing higher voltages may be needed. In some of the high-pressure, oil-filled cable lines, calibrated instruments are used at terminals to measure the traveling waves in the oil which gives an indication as to where the fault occurred. Extra-high-voltage cable lines utilizing oil pressure will probably be all equipped with such instruments for quicker fault indication.

In designing the cable samples subjected to the Cornell tests, the cable manufacturers were given valuable help by participating utility engineers in setting up requirements. One of the most important design changes was the lowering of the surge voltage which the cable samples had to withstand before submitting them to the Cornell tests.

Utility power engineers in charge of this project decided that the present art of lightning protection is sufficiently advanced that these extra-high-voltage cables can operate on most systems with a reduced built-in protection. This enabled the cable manufacturers to use paper tapes which were primarily designed to give lower dielectric losses at somewhat of the expense of being able to withstand impulse surges. Most utility power engineers and the cable manufacturers' representatives agreed that this is a sensible compromise. Some studies indicate the lightning surges are more destructive in cables than switching surges. These studies are admittedly based on meager data. However, operating experience indicates that when a cable can withstand lightning surges, it can usually and normally withstand switching surges.

While all four Cornell field test cable samples employ oil as the pressure medium, a growing percentage of cable installations in this country for 69- and 132-kv service use nitrogen. Reasons given are simplicity, economics and ease of operation with gas pressure versus oil pressure. Gas pressure cables built to operate in the 345- to 400-kv range are conceivable. What is needed is the use of gases with greater dielectric strength, or higher pressures, or both. Using gases with inherently higher dielectric strength creates a problem, however, because of their chemical reaction on the insulating material. The bottleneck to higher pressures in pipe-type cables is the terminating equipment. Perhaps these two problems can be overcome by design changes which would permit the use of gas pressure cables at extra high voltages. END

CHANGING SHAPES IN T & D

PACKAGED PLANNING OPTIMIZES FUTURE DISTRIBUTION SYSTEMS

Computer programs help power engineers solve economic problems

Robert F. Lawrence

WHETHER OR NOT loads will double in 10 years is not as important as the fact that expansion of utility systems is as inevitable as tomorrow. What is important to the power engineer in distribution and system planning is that he must continue to do a good job for the future. Part of the answer lies in new and improved equipments and construction methods. Another and important part lies in new techniques of engineering. These new techniques are available to help plan and design distribution systems and to formulate standards and policies that will yield lowest costs to serve growing loads.

Several *fully operational* packaged programs dealing with the distribution transformer-secondary system for residential areas and the primary feeder of the distribution system for any type of area are available. These programs have been developed and "tested" with utility companies and are currently in use by a number of them. Minor modifications to suit special needs are practical and can be obtained if they are required.

OPTIMIZING SECONDARIES. The importance of economical usage of distribution transformers and secondaries to serve residential loads is well illustrated by Fig. 1. The vast number of distribution transformers and the many miles of secondary mains in distribution systems emphasize that savings of a relatively few dollars per customer can be really significant. While it is not practical to optimize each transformer-secondary combination, standard designs and policies can be developed that will yield the lowest costs for loads growing with time and for conditions that are encountered in practice. Programs written for high-speed digital computers now make possible the rapid and thorough study of distribution transformer-secondary systems to determine these economic designs and policies.

The load area to which distribution transformers and secondaries are to be applied may be defined by a number of parameters which affect design choice. These parameters are initial customer demand (load class) and diversity characteristics, type and rate of load growth, secondary span length or distance between adjacent customer take-off points on the secondary main, and the number of customers served from each pole or take-off point. A typical growth trend curve is shown in Fig. 2.

It is assumed that all customers served from a transformer are of the same load class or have a range of loads that may be satisfactorily represented by their average value. It is further assumed that the radial secondary is initially symmet-

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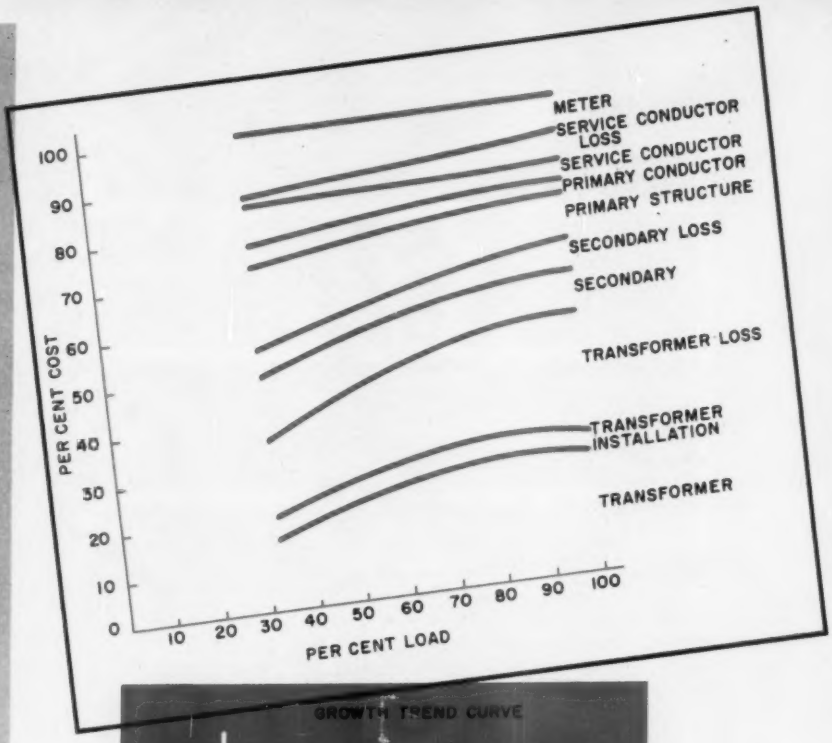
rical about the transformer location, that all secondary span lengths are equal, and that the same number of customers is served from all customer take-off points with the possible exception of the take-off points at the end of the secondary runs.

A transformer and secondary design as specified by a particular transformer rating, secondary conductor size, and number of customers served must fulfill the design or service quality limits of (1) maximum allowable transformer loading, (2) maximum allowable secondary conductor loading, (3) maximum allowable steady-state voltage drop, and (4) maximum allowable voltage dip or flicker on the lighting circuit.

Because customer load is generally assumed to be growing with time, it is necessary to evaluate the economic and functional performance of alternative design plans through some period of time. This study period is usually that for which load conditions can be reasonably approximated; i.e., 20 or 30 years. A design plan is an acceptable means of serving the growing load through the study period, starting with an initial design and modifying that design as required to satisfy all design and service quality limits at all points in time. Figure 3 shows some possible design plans for a particular load pattern.

POSSIBLE MEANS of design modification include (1) transformer changeout, (2) secondary splitting, and (3) secondary reinforcement or paralleling. Since transformer loading is believed to be the most easily monitored quantity, it is considered to be a controlling design parameter. That is, transformer and secondary combinations are designed so that the transformer will reach its maximum allowable loading (not its thermal loading which may be considerably higher) before any of the other design limits are exceeded.

At the time a transformer reaches its maximum allowable load, it is changed out to a transformer of higher rating, and design limits are checked to see whether or not the design will be adequate until time for the next transformer changeout. If the design would become inadequate prior to the time of the next transformer changeout, the secondary is modified. This modification may be a secondary split, in which case the transformer is not changed out, or secondary reinforcement. In a secondary split, new transformers of the same rating as the original transformers are set between the



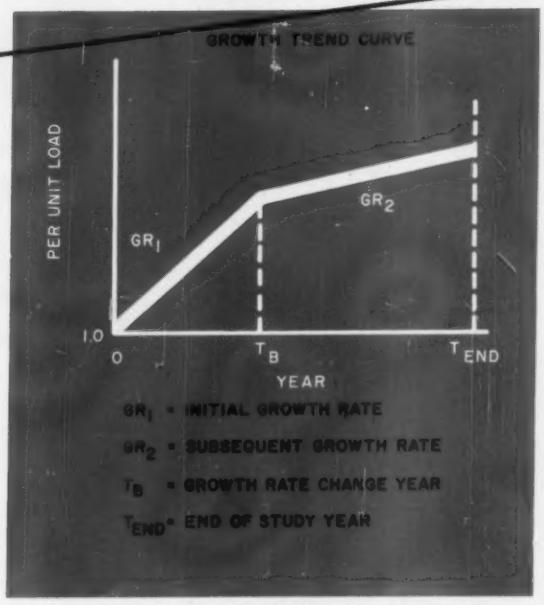


Fig. 1 (top). Division of costs of distribution system components and capitalized losses. Includes single-phase laterals, but no mains or substations. One-hundred per cent load equals 16-kva average individual demand per house. Fig. 2. Illustrative load growth trend of residential area load on distribution transformers

original transformers, radial secondaries served by each transformer are shortened, and each transformer serves half as many customers as before.

The optimum value of transformer changeout loading may be determined by considering several alternative values of maximum allowable transformer loading.

Alternative distribution transformer and secondary plans (initial design plus required modifications through time) are compared on the basis of present worth of annual revenue requirements per customer served for the specified study period. Annual revenue requirements are composed of (1) carrying charges on transformer and second-

Fig. 3. Some possible design plans through time of a distribution transformer secondary system

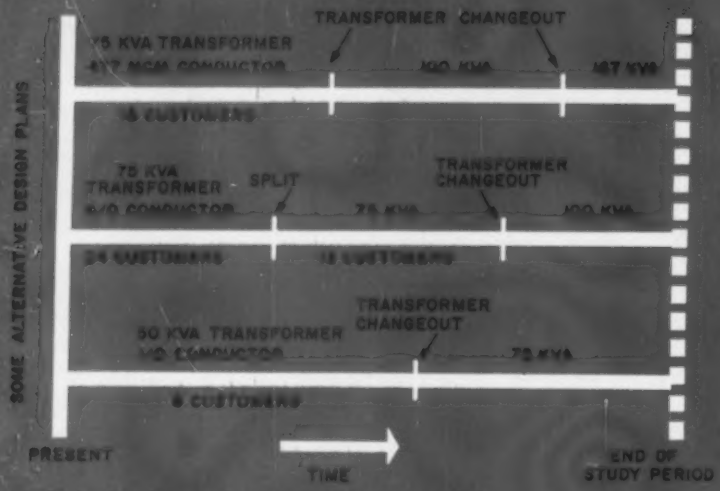
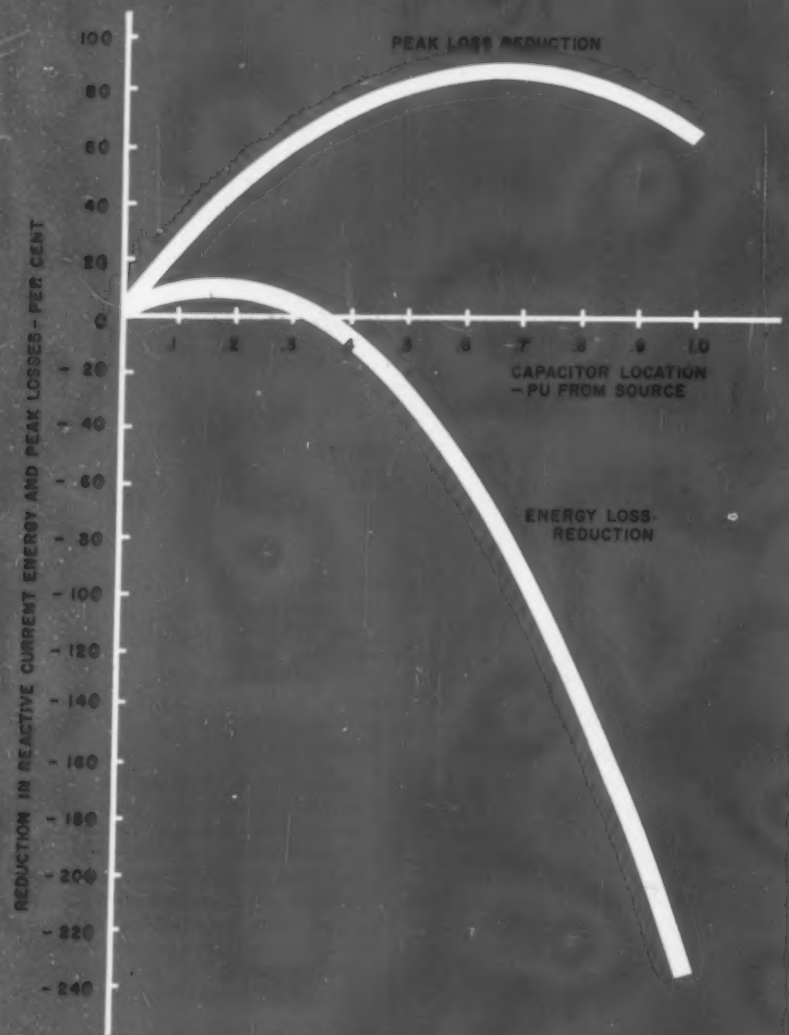


Fig. 4. Reduction in reactive current losses in a uniformly loaded feeder by the addition of a capacitor rated at 67 per cent of the peak reactive input to the feeder. Load factor is 40 per cent, loss factor is 23 per cent



ary investment, (2) applicable operating expenses such as transformer removal or secondary splitting cost, and (3) cost of losses. Some variation in accounting practices is permitted among the computer programs available so that a utility may evaluate alternatives in the light of its own practices.

For each specified load pattern, the computer program automatically develops all feasible design plans, compares these designs on the basis of present worth of annual revenue requirements per customer, and prints out a complete specification of the N lowest cost plans in order of lowest present worth cost where N is an input variable.

Studies of a large number of cases would generate literally hundreds of output sheets. These, of course, must be interpreted. Interpretation is presently done by an engineer, although new techniques are being developed for automatic interpretation.

Input data to the computer program includes: (1) load pattern specification, (2) a list of transformer ratings and their associated costs and characteristics, (3) a list of secondary conductor sizes and their associated costs and characteristics, (4) design limits and associated data, and (5) constants used in the economic evaluation of alternatives.

PRIMARY PACKAGE. A number of computer programs are available to optimize the solutions of design and engineering associated with primary feeder circuits. The fundamental programs presently available provide specific solutions to actual primary feeder circuits for such problems as basic circuit design, application of voltage regulation control equipment, and application of shunt capacitors. Also available are many modifications of these fundamental programs. These additional programs allow for alternative engineering and economic methods.

A single program is used for feeder design and for application of equipment to achieve voltage regulation control. In determining the basic design of a feeder, alternative circuit routes, voltage levels and conductor sizes can be considered to serve a specified group of loads. If voltage regulation control is required, then this is accomplished automatically by the computer. In deciding what should be done to a given primary-feeder circuit so that the desired voltage regulation is

obtained most economically, the computer program studies the following alternatives:

1. Voltage regulators only
2. Fixed capacitors only
3. Fixed capacitors and regulators
4. Fixed and switched capacitors
5. Fixed and switched capacitors and regulators

One "case" for a particular feeder would study all of these alternatives with the locations of the fixed and switched capacitors pre-selected at a particular location or "node" on the feeder. Therefore, in order to determine the most economical solution, several cases must be run with different fixed and switched capacitor locations specified. Alternative cases also are run to consider basic design alternatives.

Capacitor application computer programs utilize newly developed techniques that permit direct calculation of the optimum total capacitor rating, relative amounts of fixed and switched capacitors, and locations of the fixed and/or switched capacitors. This optimized application will result in a maximum dollar savings considering such items as energy losses, peak demand of losses, released capacity or demand reduction, and costs of fixed and switched capacitors.

Simultaneous consideration of energy and peak losses when applying capacitors is important, as demonstrated by Fig. 4. For this example, indiscriminately locating the capacitor anywhere on the feeder could result in anything from a 9.6 per cent decrease in energy loss caused by reactive current to a 232 per cent increase in the same energy loss. Locating the capacitor for maximum peak loss reduction will result in a 77.2 per cent increase in reactive current energy loss. For many years, there have been numerous techniques for capacitor application based on peak loss reduction with no consideration of energy loss.

Optimum location for the capacitor of Fig. 4 is that location which would result in the optimum total savings in energy and peak losses with an appropriate dollar evaluation applied to each type of loss. The computer programs for capacitor application, in addition to calculating this optimum location, also consider the effect on the losses of how long the switched capacitor is connected to the circuit.

Use of this package of computer programs is shown by Fig. 5. The basic feeder data, type of economic evaluation to be used, and cost information are fed into the computer along with the appropriate program. The output results from the computer include design data, economic evaluations, and circuit characteristics before and after the application of the equipment used in the design.

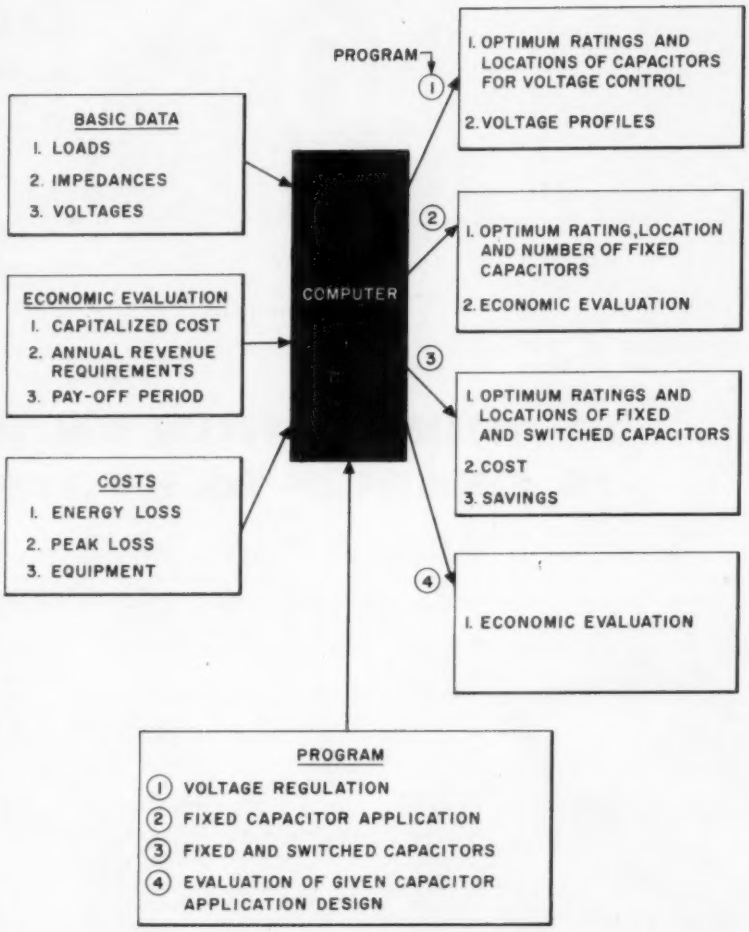


Fig. 5. Block diagram classifying primary feeder programs according to purpose and use

SECONDARY NETWORK ANALYSIS. This program is available for making an accurate analysis of a secondary network system. From basic circuit data, the program calculates system bus voltages, line power flows, and transformer loadings. Answers are printed out in a form easily understandable by a secondary network planning engineer. The program can accommodate a system having a maximum of 250 buses, a combined total of 500 lines and transformers, and up to 250 shunt capacitors. These limitations do not restrict the size of system that can be studied with this program in any way because a very large network can be broken up into several smaller overlapping sections. Each of these smaller sections can then be studied separately with excellent over-all results.

This network computer program has been used by utility companies to study normal load flow, first and second contingency load flow, fault currents, feeder loadings, and the detailed load flow in the primary feeder lines simultaneously with the secondary network system load flow. Actually, the program can be used to make an accurate analysis of any distribution circuit, no matter whether it is radial loop, or some form of a network system. The program has provisions for considering many different sources, each with a specified voltage magnitude and phase angle, feeding the same network system, and for taking into account actual transformer tap settings. END

SUBSTATION ENGINEERING IS GEARED TO SYSTEM CHANGES

What is happening to utility substations as customer demand builds the load

Harold Fossum

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He has been with Pioneer 17 years, and was formerly with Sargent & Lundy and J. S. Hartt consulting engineering firms in Chicago.

While attending the University of Wisconsin, from which he is a graduate, Mr. Fossum was elected to Kappa Eta Kappa, professional electrical engineering fraternity. He is a registered professional Engineer in Illinois and Wisconsin.

SUBSTATION DESIGN with today's changing system characteristics is a dynamic engineering problem whose watchwords are economy and reliability. Behind it is present and projected load growth. Purely and simply, increasing load means more and more substations.

Economy must continuously be sought in structural shapes, construction methods and optimum use of material; all this in the light of design parameters which include type of service (whether transmission, distribution or bulk power transfer), functions (pure switching and/or voltage conversion) and voltages served.

While each class of substation will have some common engineering problems, many changes will be different for each class.

TRANSMISSION SUBSTATIONS. Entirely different things will happen to transmission substations compared to the distribution class of station. One of the major things that will happen to the transmission substation will be higher voltages. Our present 230- and 345-kv systems—with 230 kv already quite numerous—will be increased probably to 400 or 500 kv. With these higher voltages will come many new problems.

Possibly the most serious of these will be on the transmission line. However, they will also affect the substation. Transmission substations will be of the pedestal-mounted, rigid-bus type and will require much real estate. For this reason, they will very likely not approach urban areas very closely, leaving substations in these areas to the 69-, 115-, 138- and 161-kv voltages now quite common.

Buses will be stripped of all accouterments possible. The measuring devices will be confined to the circuit breakers in the form of bushing current transformers and potential sources.

Look for a shift in the control and relaying channel from carrier toward microwave and other forms of channel which are disassociated from the line conductor.

The big problems will include corona and radio influence. RI will be much more serious for the transmission line than for the substation, but it will still be an element here.

Aluminum conductor will certainly move into the transmission substation and will take over almost as completely as it has done on the transmission line. The principal buses will be aluminum tubular bus on pedestal insulators. Reasons for this include the weldability of aluminum (see Fig. 2) and the possibility of making connectors which

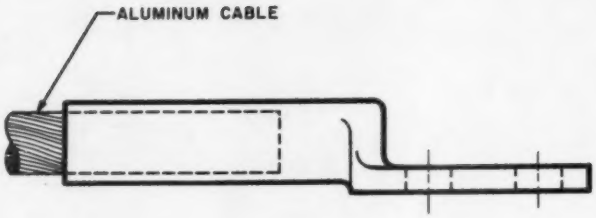


Fig. 1. Aluminum compression lugs will terminate suspension buses

have rounded surfaces with few sharp corners to cause corona discharge.

LOOK FOR multiple aluminum conductor in substation suspension buses. Connectors and taps here will be of the compression type like that in Fig. 1. The large compression units used on transmission lines will probably move into the substation, not because their strength is needed but because they are large, have rounded surfaces and will not promote corona.

Line-dropping and parallel-line switching in transmission substations will promote the increased use of the disconnecting device with an interrupting ability which is already becoming popular in stations up to 161 kv.

The pure disconnecting switch will very likely serve only to isolate a circuit breaker or other station equipment. However, where extra-high-voltage lines are terminated, look for the grounding switch to be included with the disconnect as in Fig. 3. For economy and ease of handling, aluminum will come into the disconnecting switch structure itself; the bases, the contact structures, possibly almost everything but blade and contacts themselves.

Because space in these large stations will be expensive, look for the disconnect switch consisting of a single stack with the blade making contact to a receiving element on a tubular bus as in Fig. 4.

The circuit breaker in transmission substations will go to 25 million-kva interrupting capacity, and will probably be of the air-blast type or of the gas type employing SF_6 as the interrupting medium.

Stations will largely be automatic and unattended. Relaying will be extremely high speed and with instantaneous reclosing. Transistors and computers will appear in the relaying, measuring and control systems.

Control systems will be entirely underground with the butyls and the thermosetting plastics more and more replacing the thermoplastic and rubber cable insulations.

Grounding will receive increased attention, primarily from the angle of ground gradient grids and protection of personnel from the extreme voltages which would appear at times of fault.

SUBTRANSMISSION SUBSTATIONS will probably be the transmission substations of our present systems, particularly in the urban areas. The 69-, 115-, 138- and 161-kv systems now classified as transmission will become the subtransmission stations of the near future.

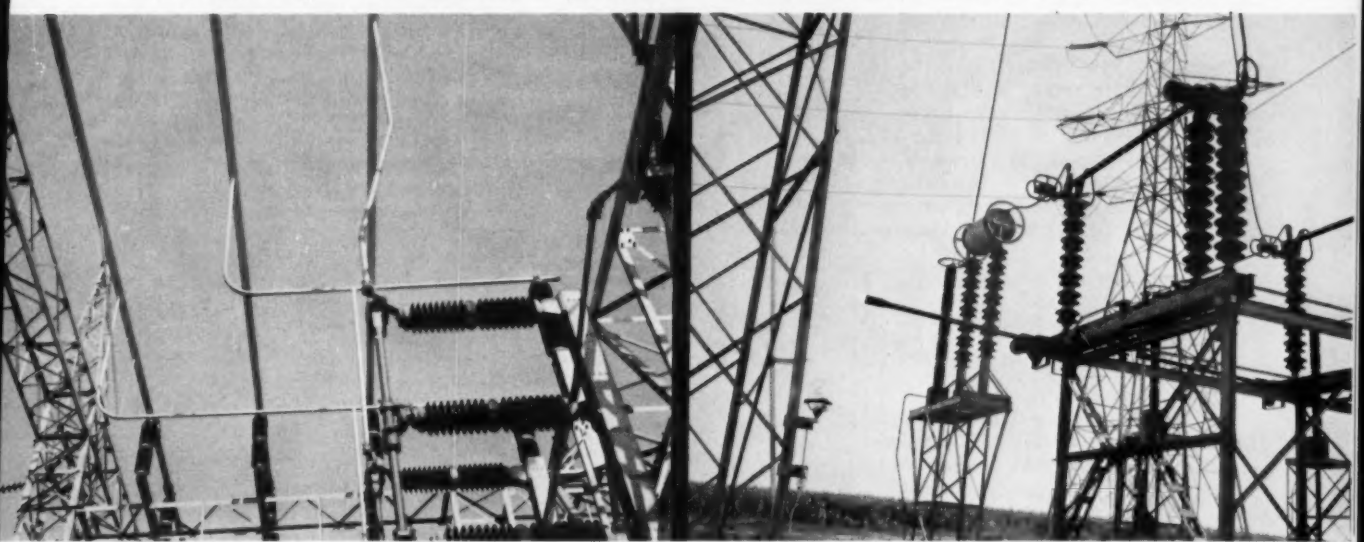
Here, too, aluminum will move in, with greater attention being given to the devices which might cause disturbances to TV and radio reception in the substation area.

Economy, ease of handling and lack of maintenance will dictate the use of aluminum in switches to a greater extent than at present in subtransmission substation structures. Unattended automatic operation will be characteristic of this system as well as the transmission substation.

Load-break disconnect switches will appear here more and more for line dropping as well as for parallel line switching. These switches will be of the types employing the vacuum tube as the interrupting device or an air circuit breaker such as is employed in the "Circuit Switcher" recently developed. (See Figs. 5 and 6.)

For the urban areas—as we move in toward the sources of generation which have in them units of tre-

Fig. 2. Welded aluminum bus helps keep corona and RI down. Fig. 3. Line termination is grounded by side blade as 345-kv disconnect is opened. Note the deadend tower for station feed, another trend



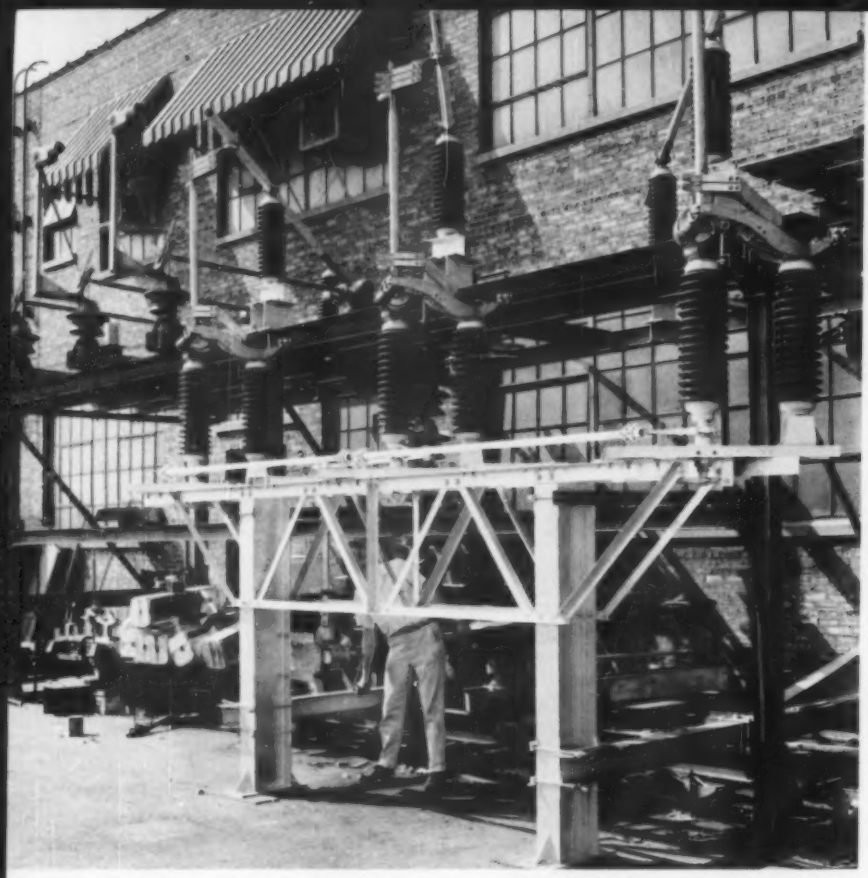


Fig. 4. This test installation of a single-stack disconnect shows its space-saving advantages

mendous capacity and where line connections become multiples — the short-circuit duties required of circuit breakers will be increasingly more severe due to higher recovery voltages.

Cost of right-of-way and public acceptance will be principal reasons why—in the urban areas—more and more substation sources and feeders will go underground at higher and higher voltages. Also, more attention will be given to subtransmission substation appearance including landscaping, lighting, and the substation buildings and structures.

DISTRIBUTION SUBSTATIONS. Keys to economy in distribution substations will be standardization, repetitive design and an increase in distribution voltages. Except for extremely dense loads, the 4-kv system will practically disappear, being replaced by the 12.5-, 14.4-, 23- and 34-kv systems.

Distribution substation transformer sizes will move to 15 to 20 mva, with each serving normally its individual block of power. The capacity will not exceed these approximate values because of the short circuit currents which would be contributed to the distribution system.

The distribution system in an average utility already represents about one-third of the cost of the entire system. To handle short circuits higher than 500 mva would increase this cost prohibitively.

More power is going to be sold at bus voltage as time goes on. The power purchaser is not going to be interested in paying large sums for a circuit breaker installation capable of interrupting 500 mva or above. Circuit breakers in distribution stations will remain conventional oil types with the recloser being used to a greater extent.

Distribution bus conductor will be of aluminum to a greater extent, with a great deal more of the structural shapes being used than in the past.

The angle shape has proved to be a very effective conductor for capacities up to and including 3000 amperes. It has the built-in economy of eliminating a great many expensive fittings, connectors and taps which are a part of the use of tubular and stranded conductor.

Since the angle or other structural shapes have flat surfaces, the connector used at the bus may be the same connector that is used on almost all other equipment, including circuit breakers, disconnect switches, current transformers, etc. in the station. See Fig. 7.

Most utilities will elect to limit the structural shape and the stranded conductor to as few sizes as possible, making it possible to take advantage of bulk purchase of both conductor and connectors that are required for the standard station.

ALUMINUM will also appear as the structural material for the distribution substation. The structural designer, with increased experience and familiarity with aluminum, will learn to apply it more nearly to its full structural capacity. In addition, the big advantage that aluminum has over other structural metals is that it may be made in almost any shape by extrusion. The structural

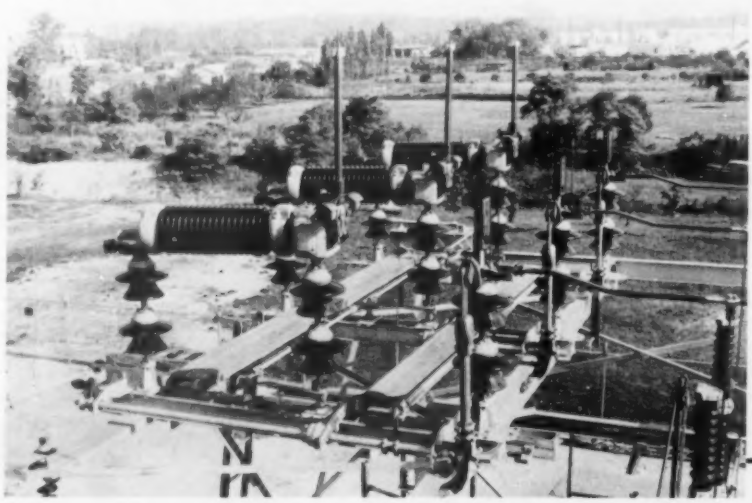


Fig. 5. Interrupting is done inside the bushing-like containers of these 69-kv, 1200-ampere circuit switchers. The blades open after interruption

Fig. 6. Vacuum tubes take the interrupting responsibility from the blades in these switches. The interrupting capacity is up to 600 amperes

shapes will be developed where the metal has been placed in the best possible position to give strength for the minimum amount of material.

One of the objections to aluminum structural shapes as conductors from operating personnel has been that it looks so much like the rest of the structure that supports it. This was solved by one utility by using colored Scotchlite tape to identify the buses. An added bonus occurred when different colored Scotchlite was used to identify different voltages where there were several in the substation.

A double dividend of increased capacity and identification has been realized by others painting the buses with a flat paint. (This would be true for copper or aluminum conductor.) It is hard to understand why more of this is not being done.

Aluminum, when new, has a heat emissivity of 0.2 to 0.3. As it darkens it is capable of dissipating much more heat and the 0.5 emissivity is now used. However, if the aluminum or copper conductor were painted with a flat paint, the emissivity factor used in the application could be 0.7 to 0.9, and could thereby almost double the particular conductor's capacity.

The normal use of aluminum in a repetitive substation structure has the advantages of being lighter, not requiring paint, being easier to handle and easier to erect. Its big bugaboo, of course, is galvanic corrosion, where aluminum is the anode in contact with almost any other material in the presence of an electrolyte. This problem will be worked out with increased use.

Appearance and public acceptance have caused many utilities to put their distribution stations in what appear to be conventional and very attractive houses with lights that go on and off very much like lights in the neighborhood houses. There is not a doubt that the utility will probably pay more attention to appearance, whether it is by use of landscaping, attractive fencing or structural design.

The distribution substation, too, will be unattended and automatic in operation. Lightning arresters will be mounted directly upon the transformers, and tap changing under load will be the most common method of voltage regulation.

MOBILE SUBSTATIONS are here to stay. They have already helped eliminate the spare transformer in substations, and will to an increasing extent replace reserve transformer capacity. Instead of buying transformers with FA and FOA ratings, utilities will begin to depend more upon mobile substations as they rebuild and add capacity to their substations.

In all substation classes, economy will be sought through standardization, simpler erection and less maintenance. END

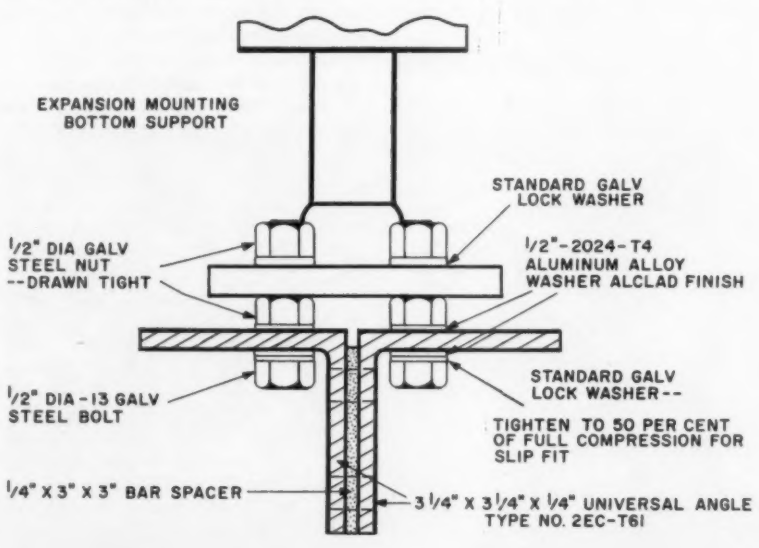


Fig. 7. Extruded aluminum angle splice is one of many economies obtainable with buses and connections to equipment terminals. All use standard bolt spacing

James H. Patton

Mr. Patton is vice-president-manager, power equipment, of Sangamo Electric Co. Closely associated with the electric utility industry for 40 years, he has had first-hand knowledge of metering trends and measuring requirements. He has been district manager of the Southwestern, West Central, and Southeastern Districts. During World War II he served as Sangamo's production manager of confidential naval contracts. Shortly thereafter, he was appointed sales manager and in 1952 attained his present position. Mr. Patton was educated at the Univ. of Michigan. He is a member of AIEE and has chaired the watthour-meter and instrument-transformer sections of NEMA several times.

COMPLEX SYSTEMS WILL REQUIRE MORE SOPHISTICATED METERING

Revenue metering has reached a high state, but operations will need more complete measurement

METERING has always followed the need to know. This has been true since the first meter was devised to measure consumption of electrical energy so that an equitable charge could be made. Once a need of the industry was made clear, the meter industry has cooperated until the electric revenue meter is, without doubt, the most accurate measuring device within the home today.

Now the electric-power utility industry has increased in complexity. Human beings are no longer physically able to gather, in time, the information necessary to operate a system efficiently. New needs for measuring and gathering accurate operating data are becoming apparent. Already the meter industry is coping with these problems, first by adapting existing instruments to new uses, and, second by developing new devices for these new needs. Complexity of this new instrumentation is increasing but accuracy must be the first consideration.

Watthour meters and demand devices have been developed to a very high degree of perfection. Close cooperation of manufacturers with meter committees of Edison Electric Institute and with the Association of Edison Illuminating Companies has provided instruments thoroughly adequate for present load conditions and for foreseeable load growth. Standards have been established for all but the most complex metering systems used for billing purposes.

This perfection is the result of improvement in all details of the meters. Thus, bearing systems of single-phase watthour meters now have life so long that experience and tests have not yet been able to determine what the ultimate may be. The same is rapidly becoming true of polyphase meters.

Load capacity of the single-phase watthour meter is, in all probability, adequate for all foreseeable single-phase loads. Rating used most is the 200-ampere meter. This will accommodate 3500 kwh per month, based upon a 30 per cent use of full meter capacity. Greater consumptions than this will probably require changes in the distribution system.

Demand meters, both thermal and mechanical, are also in an advanced stage of development. There is, today, a wide choice of capaci-

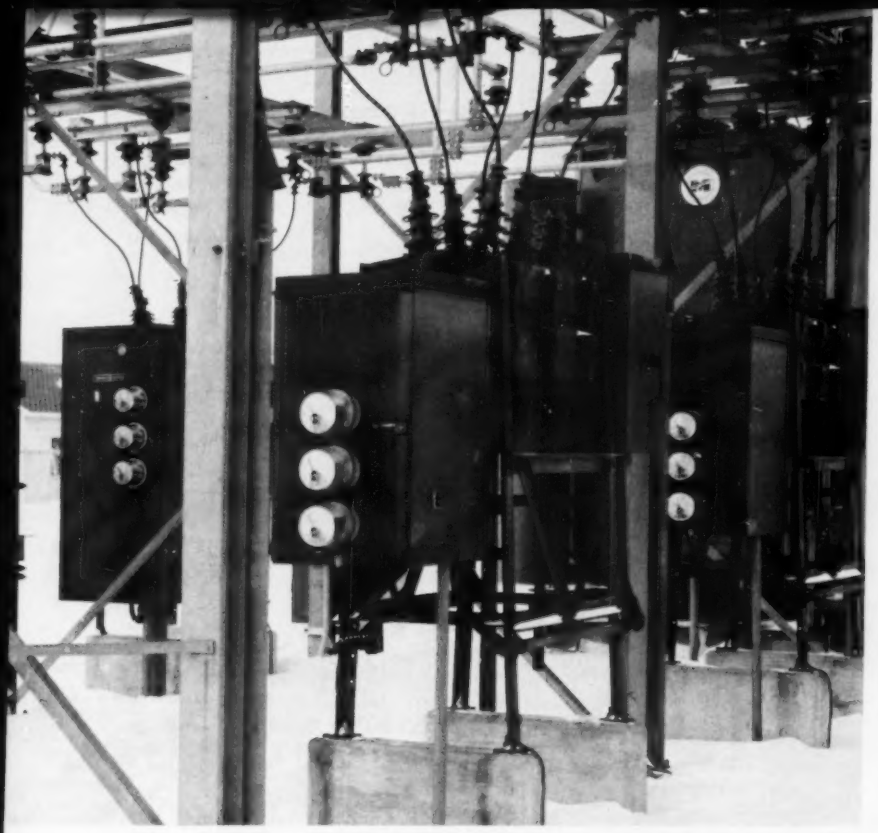


Fig. 1. Complete substation measuring scheme. Type ADS socket indicating ammeters measure loading on all feeders

ties, scale values, time intervals, and other variations that can provide accurate and reliable measurement of this increasingly important factor in utility rate schedules.

There is one aspect of revenue metering where improved instrumentation is required. Growth of large industrial loads and of multi-feeder services indicates a need for watthour- and demand-metering systems that will produce a summation of these individual registrations, improve basic accuracy, and provide means whereby such records can be processed automatically

NEED IS INCREASING in the electric-utility field for more system measurements as aids in operating and planning. Measurements of loading conditions, if made at all in the past, were generally periodic spot checks using instantaneous meters. With today's rapidly changing load conditions, population shifts, and increasing customer usage, such measurements can no longer provide enough information for a distribution engineer to keep his system adequate, let alone operate it efficiently.

Increasing use of both existing and new instrumentation is indicated for optimum operation. Inexpensive, thermal-type instruments for indicating maximum and minimum quantities over any period desired have been available for some time. Moving pointers of such instruments constantly monitor the electrical quantity for which the instrument was designed. At the same time, the moving pointer drives maximum or minimum pointers, or both, to record the greatest indication in either direction. Intervals between resetting can be for any period required.

Thermal ampere-demand meters can give the power engineer concrete information on load magnitudes, and indicate feeder balance as well. Many utilities are now equipping both new and old substations to provide these measurements. (See Figs. 1 and 2.)

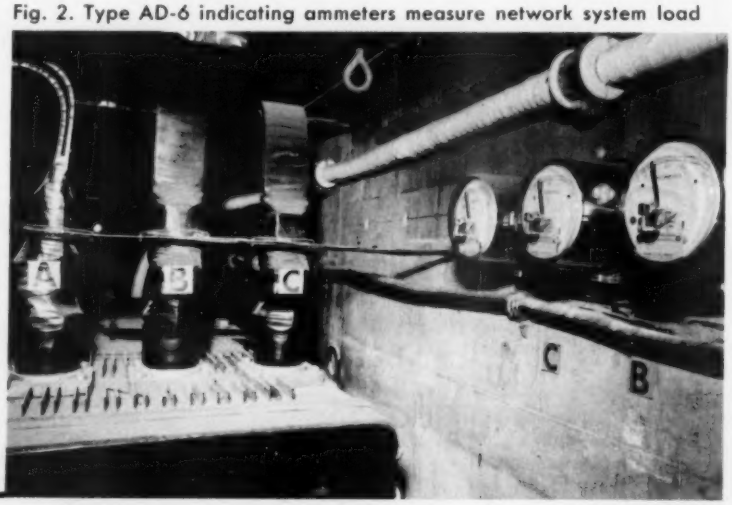
The utility power engineer needs more than an occasional voltage chart on his distribution feeders if he is to provide the excellent service required today. Continuous indication can be provided by a thermal voltmeter with minimum and maximum indications. Such a voltmeter will indicate the lowest voltage that has occurred over any period desired, as well as the highest.

More efficient operation of distribution systems also requires more accurate knowledge of system reactive. This, also, can be determined from indications of thermal meters as in Fig. 3.

More sophisticated graphic instrumentation is available that can provide a complete record, over the period desired, of instantaneous or time-lagged values of quantities being measured. These meters provide accurate information on time and duration, which is, of course, not available from the simpler instruments. Many utilities that have been using the simple instruments are now substituting the graphic type for more detailed information as in Figs. 4 and 5.

About five years ago, the need for a digital recorder that would provide a record subject to translation to IBM cards and punched or magnetic tape was recognized. This development has progressed, and numbers of these instruments are being used for billing measurements, sub-

Fig. 2. Type AD-6 indicating ammeters measure network system load



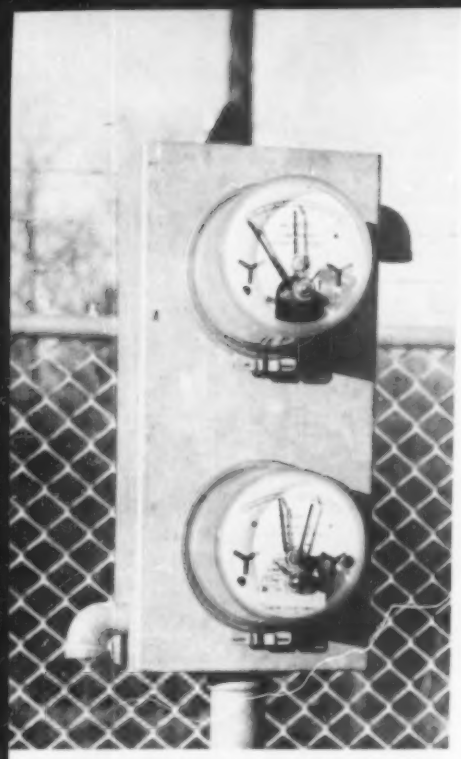


Fig. 3. Indicating kw (Type WDS) and kvar (Type VAS) meters measure feeder loading. They can be replaced by graphic kw and kvar meters

station measurements, and load-survey work. See Fig. 6.

Needs for more and better measurements on distribution feeders have been outlined here. Important loads on subtransmission and transmission circuits require at least the same, or probably more complete measurements.

MORE INSTRUMENTATION has been done in the generation field during the past than in any other portion of the electric-utility field with exception of the complete measurements required for revenue purposes. Most of this instrumentation has been of instantaneous values; however, integration over time periods is becoming increasingly important. The use of digital instruments whose record is subject to automatic data processing will also become more frequent.

Present methods of even the larger utilities in computing their sixty-minute hourly demands leaves much to be desired from the standpoint of accuracy and ready availability. Increasing need for automatic operations such as use of high-speed computers, new transducers, and data logging is becoming evident. Instruments of this type are generally designed for specific needs. However, development work is now progressing on module units that will read sequentially a number of instruments and tape their readings continuously.

Automation of reading, data logging, and storing will become increasingly necessary as systems become more complex and it becomes relatively more and more impossible for human beings to evaluate the multiplicity of information necessary for long-range planning.

REVENUE METERING must serve rates. Rate concepts will determine direction of metering in the future. Recently there has been some trend away from special residential rates involving demand, or load factors, or time control. This is despite the fact there has been no evident change in basic thinking of utilities regarding necessity for a factor in rate structures recognizing fixed charges in system operations. Mainly it appears to be caused by a lack of customer understanding of the concept of demand.

Attempts to average within a rate structure the great divergence between load factors of individual residential customers, and thus avoid separate demand charges, have not been too satisfactory.

Perhaps reselling load-factor measurements on the basis of a bonus for good load factor rather than as a penalty for bad load factor will give the utility industry a firmer base for expansion of residential demand measurements of the future.

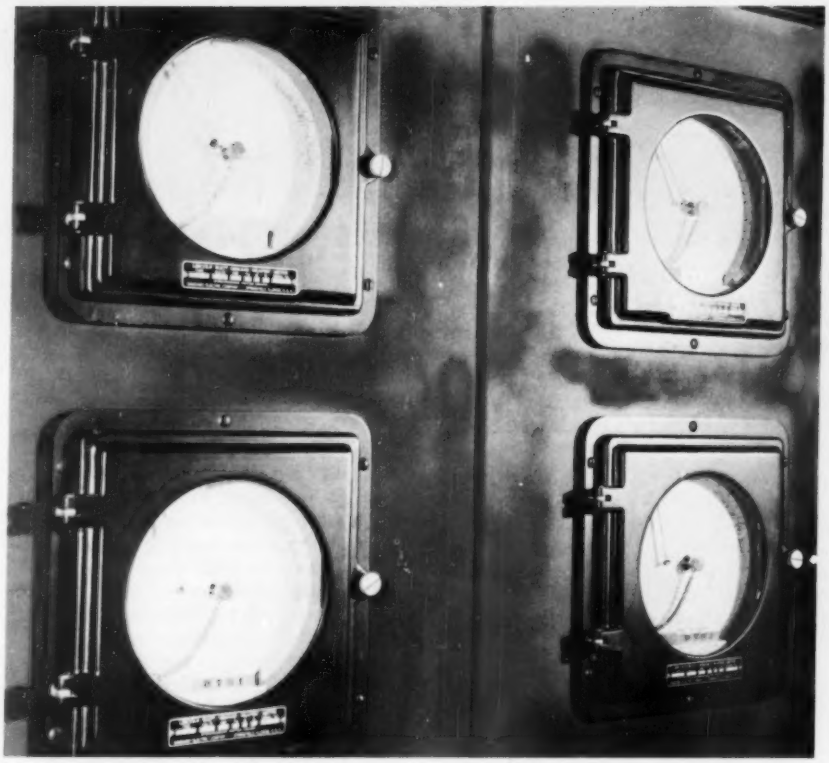
Increasing consumer demands, led by expanding use of electric space heating, will require a re-evaluation of this whole concept of residential load-factor measurement.

Industrial revenue measurement will become more complex as loads increase. Multi-delivery-point measurement with totalization, telemetering, and automatic data logging will become more common. New and improved impulse devices having the capability of more frequent pulses in each time interval are now available for such uses. Advantage of increasing number of pulses in each time interval for a given reading is that it improves accuracy since each pulse conveys a proportionately smaller bit of information. Instruments are now available with such high pulse rates that on a total demand of one-million kw, each pulse need have a value of only one kw. These pulses can be supplied to data-storage equipment for scanning at pre-determined intervals, for totalizing, or for other uses.

REMOTE READING. Remaining link in improving residential meter reading would be in automation or remote reading. Thorough research of industry developments, including that of our own organization, indicates that probably the most economical system will involve use of existing telephone lines without interfering with their normal function.

Fig. 4. Type CCV Lincoln graphic voltmeter is used here to record voltage at service entrance of last customer on a feeder

Fig. 5. On switchboard a pair of Type CCW (kw) and Type CCVAR (kvar) Lincoln graphic meters measures subtransmission circuits



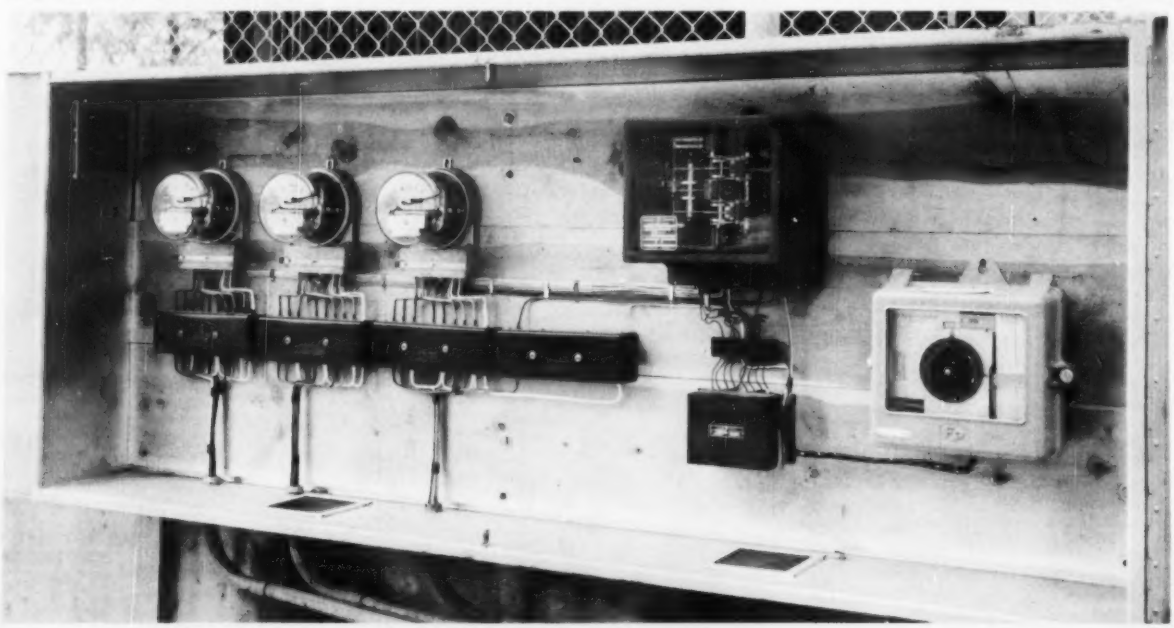
One such system would involve automatic dialing at the telephone central of the customer's telephone number and automatic response by the customer's meter of its reading at that moment. This response would then be fed to a tape or similar memory device from which the bill would be computed.

Present estimates of manual-method meter-reading costs run from one to three dollars per year, depending upon frequency of reading and geographic layout of the system. It does not seem possible at the present time that meters can be read automatically with the same economy as with the manual system.

However, any automatic meter-reading system provides the possibility of many additional functions other than simple monthly readings. For example, a group of meters, selected at will, could be read as frequently as desired. A company having such a system could make load surveys wherever and whenever conditions required. This corollary benefit should be given full weight in evaluating economies of automatic meter-reading systems. It is hoped that some way will be found to put a price tag on these benefits.

There has been some interest in the industry in an hermetically sealed watthour meter which would be proof against contaminants of all kinds in the atmosphere. Meters of such construction were designed over five years ago, and quite satisfactory results were obtained. However, difficulty of manufacture has indicated that the completely hermetically sealed meter must be a more expensive device than the meter of today and not practical for normal operating conditions. Special conditions involving a corrosive or foreign-matter-laden atmosphere are probably not sufficiently numerous to require large production, and costs must of necessity be high. END

Fig. 6. Large hospital load is totalized and recorded by Type DDR digital demand recorder. Punched paper tape is then automatically processed by IBM equipment



DIRECT-CURRENT POWER TRANSMISSION

Pros and cons of D-C as viewed by British expert

Dr. Colin Adamson

Colin Adamson recently became head of the Electrical Engineering Department of The Manchester College of Science and Technology in England. He has the degree of Doctor of Science and is a recognized authority on static relays and power systems. He is an editorial adviser to the staff of the English magazine Direct Current.

USE OF D-C for the long distance transmission of electrical energy dates from the days of the French engineer Thury, who designed the system from Montiers to Lyons in the early days of the present century. This system had a capacity of 20 Mw, extended over 138 miles (23 miles of cables) at a voltage of 125 kv, and operated on the basis of constant current supplied by several series-wound d-c generators connected in series. This was the high peak of d-c techniques for almost half a century until experimental transmission connected over 61 miles of cable between the Swedish mainland and the Baltic island of Gotland. On January 1, 1956, this system was taken over by the Swedish State Power Board for normal commercial operation.

A 70-mile-long line is now operating in the Soviet Union, between Kashira and Moscow, at 200 kv dc and carrying 30 Mw on an experimental basis. Also, construction has started on the large Stalingrad-Donbass system, some 300 miles long and designed for transmitting 750 Mw at 800 kv dc.

In England and France, technical studies of the way in which these two, very large, electricity systems (combined capacity of the order of 50,000 Mw) could be connected together, were proceeding. Attempts to find a preliminary solution with a four-core, 132-kv a-c cable failed, particularly in respect to the enormous proportion of reactive power in terms of the real power capability of the cable. A d-c cable shown in Fig. 1 was laid in the English Channel in the summer of this year and the converter stations (see Fig. 2) about 35 miles apart, at Lydd and Boulogne, are in a very advanced stage of construction. This transmission will be at 160 Mw, 200 kv. Economic advantage is being taken of a difference in peak hours in the two countries; the system is not being built for major power transfer with a large net annual import or export figure for either country.

Advantages of such a d-c system are manifold. Firstly, there are no problems from the stability or frequency regulation points of view since the scheme is asynchronous. Secondly, the d-c cables are much lighter in weight than the corresponding a-c cables for the same power transfer. To illustrate this remark, a ± 100-kv d-c link with two impregnated power cables of 340 sq mm copper sections is adequate to handle the required 160 Mw; with ac, however, at what for England is a standard cable size of 132 kv, three pressure-type cables of the same cross section would be required. Furthermore, because of the difference between the admissible voltage gradients for d-c and a-c cables, d-c cables derive a further advantage. In the channel crossing the weight of each of the two d-c cables is 33 kg per meter, where it would be 75 kg per meter for each of the three a-c cables mentioned above. Thirdly, the losses with the d-c system are only a third of the losses for the corresponding a-c system for the same power transfer; these losses are not negligible, being about 0.15 Mw per kilometer or 9 Mw total at full-load.

Economic advantages of dc over an equivalent a-c system may be

One of the most recent general overhead line assessments gave this result:

d-c			a-c			
MW	KV	No. of rectifier groups in series per phase	MW	KV	No. of cables per phase	Critical Distance
2 x 750	2 x 400	2 x 4	2 x 750	400	2	320 miles
2 x 375	2 x 300	2 x 2	750	400	1	390 miles

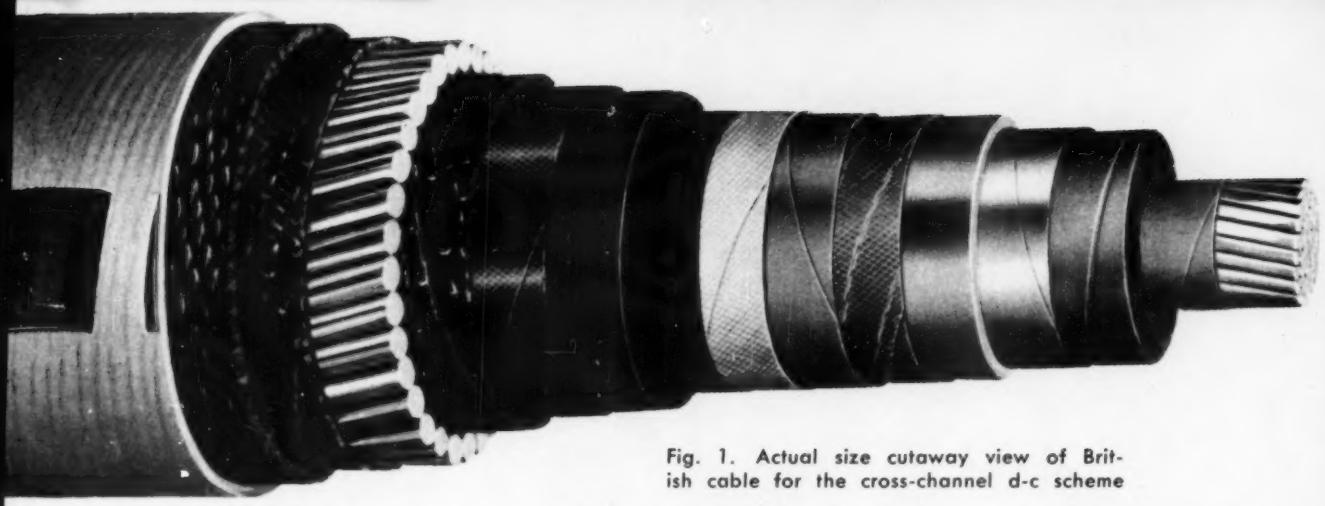


Fig. 1. Actual size cutaway view of British cable for the cross-channel d-c scheme

briefly summarized as follows: Net capital saving is about $1.5 million, the saving from the use of d-c cables of $4.8 million being partially offset by the extensive and expensive converter installations of $3.3 million. The total capital cost will be slightly in excess of $15 million.

OPERATIONAL ADVANTAGES provide the major justification for the scheme. There will be savings from discriminatory starting up of thermal plant in the two countries, and from exploiting the difference in marginal costs of generation in the two countries. In the latter case, it has been estimated that the annual savings from fuel economy alone will considerably exceed $1 million.

A New Zealand project is very interesting in its requirement for 335 miles of overhead transmission line, in addition to the cable crossing of the Cook Straits. Clear advantage lay with dc for this project. The cheapest a-c scheme considered was $22.5 million more than the d-c scheme, and, the transmission losses in the d-c scheme will only be 50 Mw at full load, compared with 100 Mw for the cheapest a-c scheme; if this difference in cost of losses is related to capital charges, it gives a further $11 million advantage in favor of dc.

There is also substantial interest in Southern Europe in a system extending between Sardinia and the Italian mainland. Coal is available in great quantity, but poor quality, at the Sulcis mines on the island, and proposals for d-c transmission using a 100-mile-long cable working at 200 kv dc are under active consideration.

WATER CROSSINGS introduce heavy bias in favor of dc, particularly because the only charging currents are those due to harmonic voltages and are very small. The optimum length of d-c cable may thus be determined from the distance at which it is necessary to supply a-c charging current at an intermediate cable point. The steady-state charging current for a 3-phase cable is of the order of: 2 mva/circuit/mile at 132 kv, 5 mva/circuit/mile at 220 kv, 15 mva/circuit/mile at 400 kv. Distance limits corresponding to these are usually taken as: 40 miles for 132 kv, 25 miles for 220 kv, and 15 miles for 400 kv.

For purely overhead line applications, the situation is not so clear cut. A few years ago, it was customary to make the comparison between ac and dc on a basis of finding the length of line for a break-even in cost, assuming a given power transfer. On this basis, there is clearly a distance at which the decreased cost of d-c line losses compensates for increased capital costs for d-c terminal equipment.

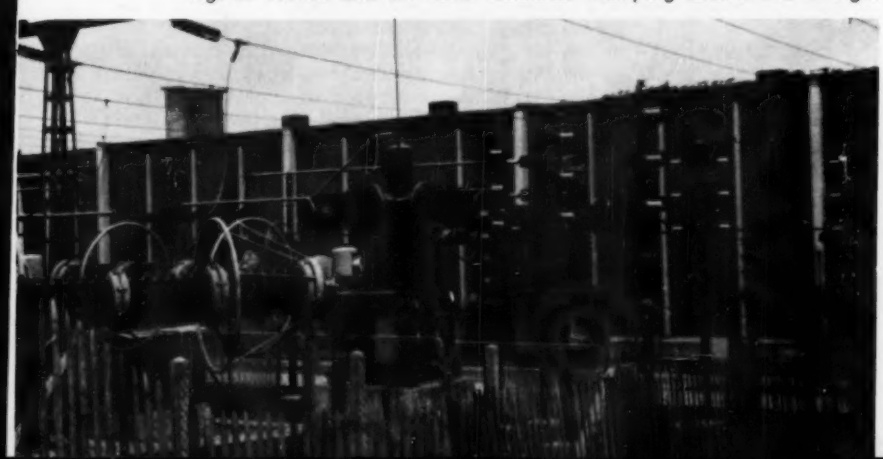
Three circumstances render the comparisons shown in the table on page 76 inadequate:

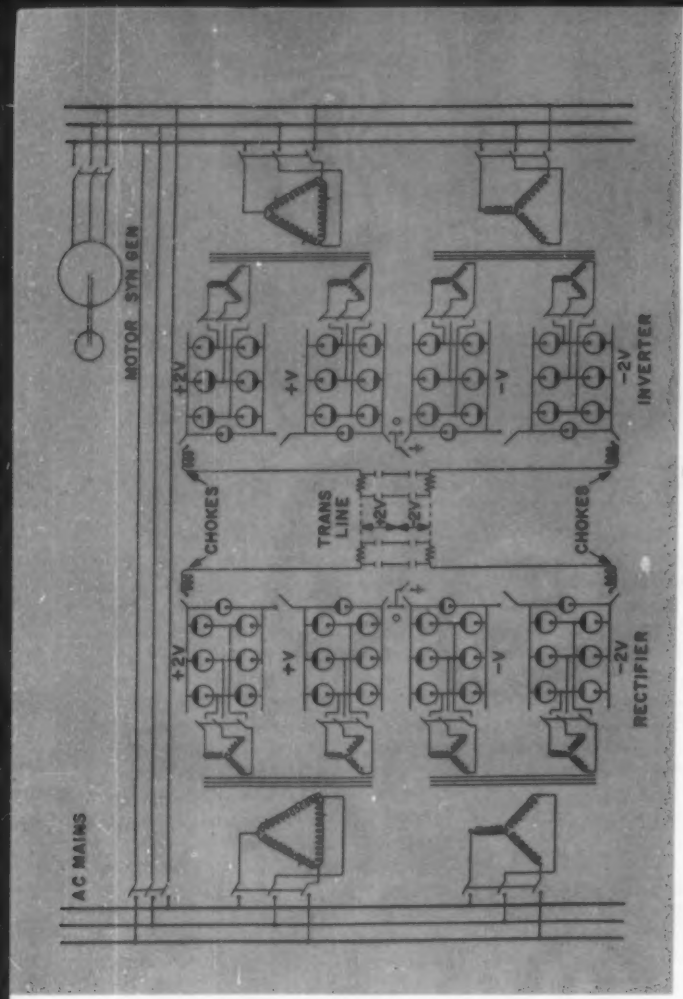
1. Economic distance is irrelevant in some cases where legal and other non-engineering factors become prominent. Thus in some crowded cities in Europe and North America, where rights-of-way for overhead lines are increasingly difficult to obtain, the case for bringing electrical power into the cities using either existing a-c cables converted to d-c, or by new d-c cable systems, is being actively studied.

2. Requirements for transmitted power are continually rising. Even in England and Wales, with a high average density of installed electrical capacity over the total area of 58,000 square miles, of 0.5 Mw/square mile, and notwithstanding the relatively short distance between terminals, it is possible to think in terms of d-c overhead line transmission systems if the Mw transfer is high enough.

3. Any modern comparison of costs will not necessarily be on a basis of dc versus ac. Since the basic problem is energy transfer, it is necessary to take into account both modern pipeline technology and newly discovered sources of oil and natural gas. A recent estimate from the Soviet Union is of interest in this respect; the index of specific capital expenditures comes out to be the same, over a distance of 1000 kilometers, for an oil pipeline of 72 cm diam with a freight capacity

Fig. 2. French end converter terminal. Damping circuits are at right





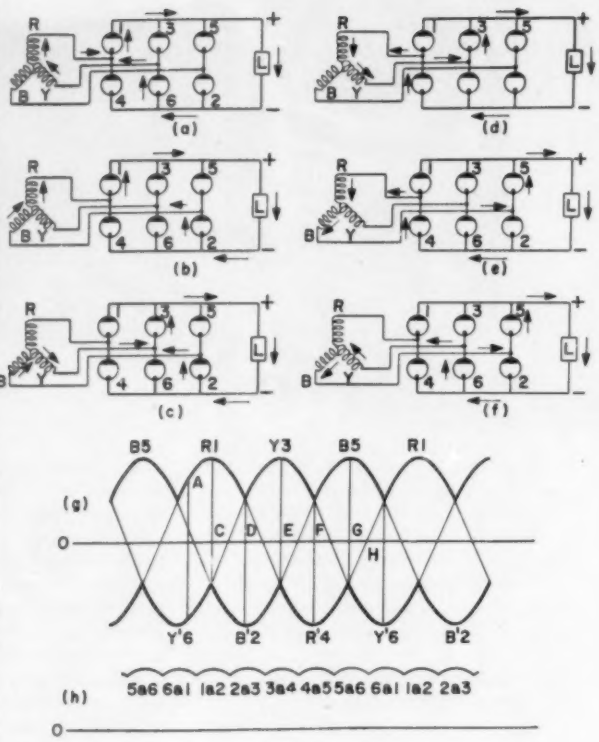


Fig. 3. (above). Bridge connection for rectification.
Fig. 4. Laboratory circuit with two bridges supplied by each transformer. System voltage is ±2 V

of 11 million tons per year, a gas pipeline of 102 cm diameter with a capacity of 10,000 million cubic meters per year, and for high-voltage d-c transmission at 1200 kv (±600 kv) of 15 million Mwh per year. If this index of specific capital expenditure is assumed to be 100, then the same energy transfer over the same distance would cost 127 for an alternating voltage of 600 kv between lines.

These Russian figures emphasize that high-voltage dc at hitherto unconsidered power transfer levels can compete with coal transfer over a first-class railway and, for example, a specific capital cost index of 100 is also quoted for a railway system capable of carrying over 25 million tons of coal per year.

AVAILABILITY OF NATURAL GAS from North Africa to provide energy for Sicily, Southern Italy and Southwest Spain is another interesting consideration. Methane carrying ships cannot in this case compete with a gas pipeline because of high liquefaction costs with regard to short sea distances involved. Almost any reasonable size of pipeline will be economic compared with sea bed transmission by high-voltage dc. The reason for this is of considerable importance and has already risen in connection with the New Zealand high-voltage d-c scheme; this is the present limit of power transfer over single cables which is of the order of 400 Mw at a voltage of, say, ±250 kv dc.

At present the highest voltage which has been discussed is 800 kv (±400 kv) in connection with the 500-Mw transmission from Stalingrad to the Donbass. Aside from questions of cables, the power transfer capabilities and voltage ratings depend mainly on the converters.

A converter station should be able to rectify or to convert from dc to ac; i.e., invert. The transition from rectification to inversion is accomplished by altering the firing angles of the various rectifiers in a converter group in sequence and arranging for the supply of reactive power to the inverter, since the d-c system by its very nature cannot supply this. The most satisfactory system of connection is a 3-phase bridge connection. This is illlustrated in Fig. 3, which for simplicity shows the d-c transmission system simply as load L.

In the bridge connection it can be seen that two rectifiers are connected to each phase terminal, the one with the anode connected to it (shown on the upper side of the bridge) and the other with the cathode connected to it (shown on the lower side of the bridge). Thus when the current is flowing out of the phase winding, it flows through the upper rectifier. This occurs when the phase voltage is positive; that is, when the anode voltage of the upper rectifier is positive with respect to its cathode.

Similarly, when the current is flowing into the phase winding it flows through the lower rectifier, and this occurs when the phase voltage is negative; that is, the cathode voltage of the lower rectifier is negative with respect to its anode.

Starting at point A, phases R and Y are conducting through rectifier 1, the load, and rectifier 6, as shown in Fig. 3 (a). This state continues up to point C, after which the cathode of rectifier 2 becomes negative

with respect to the cathode of rectifier 6, and commutation takes place from 6 to 2; that is, from phase Y to phase B. Now phases R and B conduct through rectifier 1, the load, and rectifier 2, as shown in Fig. 3 (b).

After point D the anode of rectifier 3 becomes positive with respect to the anode of rectifier 1, and commutation takes place from 1 to 3; that is, from phase R to phase Y, Fig. 3 (c). This is followed by commutation from 2 to 4 at point E; 3 to 5 at point F; 4 to 6 at point G, and then 5 to 1 at point H. This completes the whole cycle; thus the output voltage is shown by the thick line, Fig. 3 (g). Figure 3 (h) shows that it has a ripple of six times the main frequency. Each rectifier carries the full value of system dc for 120 degrees, and there are always two rectifiers conducting in series.

Possibility of using one transformer, with two secondaries and one primary to connect two bridge units is attractive, and such an arrangement is shown in Fig. 4, an elementary diagram of a system in use in the Power Systems Laboratory of Manchester College of Science and Technology. The two secondary windings of any one transformer may have different connections; i.e., the one in star and the other in delta.

MOST IMPORTANT ADVANTAGE of two secondaries and one primary is economic. A further merit is that when a fault caused by a rectifier backfire occurs on any one of the secondaries, the short circuit current in the primary will be due to one secondary fault; as the primary is designed for the current of two secondaries, the tendency will be to produce less severe stresses on the transformer; this depends, however, on the precise winding arrangement.

There are, however, disadvantages with such a scheme. If, due to a backfire, there is a short circuit in one secondary winding, it will result in a fall of voltage and consequent fall of magnetic flux in the core of the transformer. This will reduce the voltage induced in the second secondary, but due to the self-capacitance, mutual capacitance, and capacitance with respect to earth, this sudden change in flux causes high-frequency oscillation in all windings. This may cause a breakdown of any rectifier in the other secondary, and may thus result in a double short circuit and a much more severe fault condition.

Customary method of avoiding such difficulties is to provide a high degree of screening, a surge diverter across each winding, and adequate damping circuits. This protective equipment is necessary also to take care of the oscillation produced by the commutation process.

Advantage of connecting rectifiers in series, as distinct from bridges in series, is that the increase in converter rating is obtained by the provision of one large capacity transformer rather than a number of small ones. Connecting rectifiers in series is not, however, a very straightforward matter. Each rectifier cathode, together with its auxiliaries, has a large capacitance to earth, whereas between adjacent rectifiers, the capacitance is small. The resulting voltage distribution is uneven with the highest voltage occurring across the rectifier with the highest potential with respect to earth.

BETTER VOLTAGE DISTRIBUTION can be obtained by using potential dividers across the series arrangement of rectifiers. Combined resistance capacitance dividers are desirable. These provide best voltage distribution under transient conditions, and mimimize parasitic oscillations which accompany sudden voltage change ensuing from starting and stopping of the rectifiers. In view of the large stray earth capacitance of the cathode and its auxiliaries, it is impracticable ever to consider more than, say, four or five rectifiers in series.

Series connection of rectifiers may reduce the incidence of "arcing-through"; i.e., the failure of grid control. If one rectifier of a chain fails for this cause, the others will prevent the series combination from conducting. At the same time, the chances of ignition failure of the series combination may increase if one of the rectifiers fails to fire. These faults have adverse effects on inverter operation and cause system short circuits.

With two rectifiers in series, failure of one will put the whole of the voltage across the other; if partial failures are not rare, then each must be built to withstand full voltage, and the rated voltage of a bridge unit cannot be increased beyond what would have been the case with only one rectifier per arm, although a great reliability would be achieved. Advantage in this respect thus lies with three or more in series, each rectifier being designed for a proportionate share of overvoltage in the event of one of them failing.

Parallel connection of rectifiers reduces the incidence of shutdown due to ignition failures, since the companion rectifier will continue to conduct although it will be overloaded. This is probably well within its capability for a period of a few cycles. Alternatively two or more parallel-connected anode structures may be provided with a common tank and cathode. Development in Sweden indicates that a rectifier of any current capacity can be made economically by increasing the number of anode structures in parallel.

Rectifiers in series increase the reliability of the bridge into which they are connected and hence the reliability of the transmission system. Bridges-in-series, however, increase the reliability of the transmission system in the event of failure of a bridge, and in the same event decrease the transient overvoltages and currents associated with the remaining bridges. Thus the greatest reliability of converter plant is obtained by compromise.

For economic reasons the total number of rectifiers is likely to be dictated largely by the maximum size available. At the same time, it is very desirable to provide a minimum of two bridges in series, one of each polarity with respect to earth, irrespective of the maximum size available.

AVAILABILITY OF RECTIFIERS with ratings of 100 to 150 kv, and several thousands of amperes would make possible a further breakthrough in favor of high-voltage d-c transmission. This is a substantial part of the research program of the new laboratories at present being established by the United Kingdom Central Electricity Generating Board at Marchwood.

At present, or hoped-for, ratings it is impossible to consider seriously the application of controlled semiconductor devices for static power conversion at this level. Work in numerous centers continues, but the ratings are at present insufficient by at least two orders of magnitude, and it is too early to say whether or not a breakthrough will be possible. Meanwhile, extensive work on mercury arc rectifiers continues.

High-voltage dc is now an established fact and is making a challenging claim for a place in the power transmission networks of the future. All the signs are that it will increase and not diminish in either application or importance. END

Dr. Richard McFee

Richard McFee is Associate Professor, Department of Electrical Engineering, Syracuse University. Born in 1925 in Pittsburgh, Pennsylvania, he received his B.E.E. at Yale. His graduate work includes a M.S. in Physics at Syracuse University and a Ph.D. in E.E. at University of Michigan. He has had experience in Army Signal Corps, Bell Telephone Laboratories, and has been in his present position four years. His research efforts include Biophysics, Circuit Theory and Cryogenics.

SUPERCONDUCTIVITY – CRYOGENIC KEY TO LOW-LOSS T & D?

Superconducting transformers and transmission lines offer prospects of higher efficiency

INTEREST IN superconducting transformers and transmission line possibilities has been stimulated by the ability of supercooled wires of lead, niobium or other superconducting materials to carry current with no heating whatsoever. The economic prospects of these devices are not trivial.

Consider the potential advantages of eliminating transformer winding resistance. In a modern 100-mva 60-cycle transformer, copper loss is about 400 kw and core loss 100 kw. If the wire resistance were zero, the winding loss would disappear and efficiency would rise from 99.5 per cent to 99.9 per cent. But since no heat would be generated in the coil, the current rating could be increased. If the current could be increased by a factor of five, transformer efficiency at rated current would become 99.98 per cent and the rating 500 mva. Furthermore, transformers with ratings of two or three thousand mva could be shipped on freight cars. Thus the economic advantages include not only lower losses, but also smaller size and lower initial cost.

Cost of losses in power distribution systems is several hundred dollars per kw. Elimination of losses in a 500-kva transformer of 99.5 per cent efficiency would mean savings of about one million dollars.

By the same measure, elimination of losses in a 500-Mw transmission line operating at 98 per cent efficiency would mean a saving of several million dollars. With underground superconducting cables, the high cost of rights-of-way would also be reduced.

BASIC CONSIDERATIONS. The design of superconducting transformers and transmission lines is controlled by several factors. Among these are the quenching of superconductivity by magnetic fields, the economics of low-temperature refrigerators, the magnitude of dielectric losses, and dielectric breakdown at low temperatures.

Quenching of superconductivity by magnetic fields (Fig. 1) determines the maximum currents at which the devices can operate. In transformers of ordinary design, utilizing ordinary superconductors such as lead and niobium, this maximum value is considerably smaller than the rating of a conventional transformer of the same size. The author has shown recently that this difficulty can be circumvented by interleaving the primary and secondary windings.

A similar procedure can be used with transmission lines. An alternative approach is to use the recently developed "exotic" types of superconductors which quench only in very strong magnetic fields A disadvantage of the interleaving approach is the high stress placed on the electrical insulation. High cost of fabrication, the possibility of substantial "hysterisis"-like losses in the conductors, and extreme forces during short circuits are likely to prove troublesome if "exotic" superconductors are used.

Low-temperature refrigerator efficiency is very small. In modern refrigerators every watt of heat extracted from a region at the temperature of boiling helium (4.2 Kelvin at normal atmospheric pressure) requires one to three thousand watts' input to the refrigerator motor. Chief among several reasons why the efficiency is so poor is the second law of thermodynamics. It states that an ideal heat engine can be made nearly 100 per cent efficient if it is operated with a heat sink near absolute zero. The same principle establishes that a low temperature refrigerator, which is really a heat engine in reverse, will have a very low maximum efficiency. An ideal refrigerator cooling boiling helium at atmospheric pressure would require a little less than 100 watts of power input for every watt extracted. In practical refrigerators small heat leaks and various loss mechanisms increase this to the much higher value given previously.

Because of the unavoidably small efficiency of low temperature refrig-

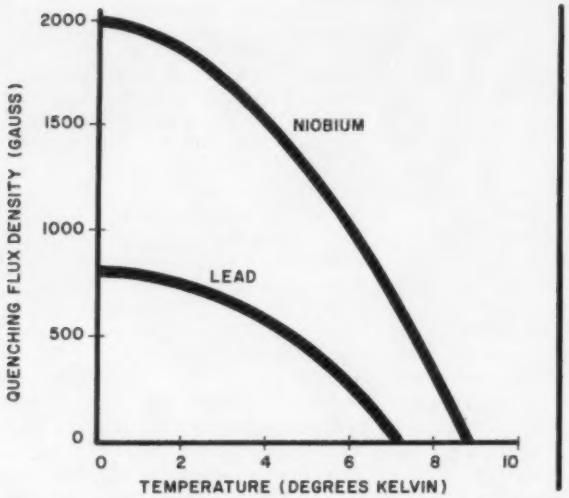


Fig. 1. Lead and niobium quenching levels. Field can be generated in superconductor or by external magnets

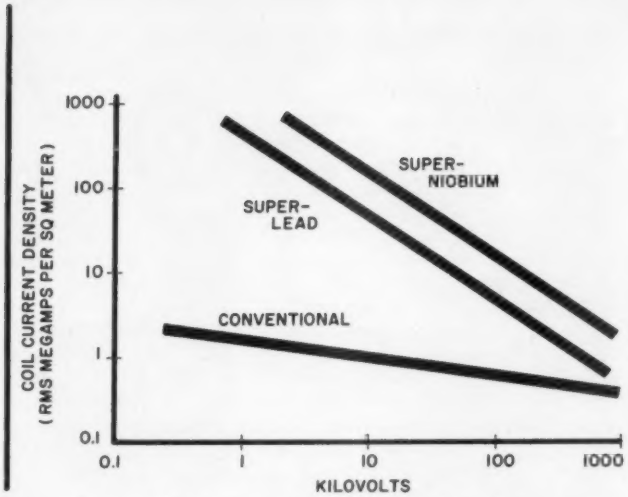


Fig. 2. Maximum coil current densities for conventional and superconducting transformers. Note log scale

erators, reduction of the thermal load is a fundamental problem in superconducting apparatus. In transformers, the core losses are much too great to be handled by a refrigerator of reasonable size and power input. Thus the core must be operated at room temperature, a procedure which introduces difficult but not insoluble design problems.

Superconducting transformers and transmission lines require the very highest quality thermal insulation, such as that provided in a vacuum flask where high vacuum separates shiny metal surfaces. Multiple metallic surfaces can further decrease the thermal conductivity, and astute use of heat shields at various intermediate temperatures is capable of greatly reducing the refrigerator load. The input leads entering the low temperature region must be carefully designed, so that they are not too short or thick, thereby conducting too much heat, nor too long and thin, thus generating excessive heat by ohmic losses. When the input leads are properly designed, each ampere of current carried in or out of the low temperature region requires one or two watts of input to the refrigerator.

Most refrigerator load comes from heat introduced by the input leads. Since refrigerator power is a major loss in superconducting power apparatus, their efficiency is better at high voltages and low currents, so slender input leads can be used.

The magnitude of dielectric losses at cryogenic temperatures is as yet uncertain. It is known that the loss tangents are quite small, but the precise values for ordinary insulating materials is still a matter for speculation. Since no heat is generated in superconducting wires, a heat transfer medium is not required and vacuum insulation may be used, with resultant elimination of the dielectric loss factor.

Experiments have shown that the dielectric strength of common insulation materials (varnished paper, mylar, teflon, and polyethylene) in liquid nitrogen and liquid helium slightly exceeds the values at room temperatures.

TRANSFORMERS. At Arthur D. Little, Inc., a small superconducting transformer has been built and operated at 2.2 kv and a power about 15 kva. The coil was built up with 20 primary (P) and 20 secondary (S) layers of lead wire interleaved in the sequence P-S-S-P-P-S-S-P . . . . P-S-S-P. Primary and secondary windings were insulated with varnished paper 0.01 in. thick.

The entire assembly was evacuated including core, coil, and vessels containing liquid nitrogen and helium. Thermal insulation was provided by burnished copper sheets maintained at liquid nitrogen temperature. At the maximum power level, passage through the winding of a direct current of about half an ampere produced no deflection in a sensitive galvanometer capable of detecting less than half a microvolt. Resistance of the two miles of wire was less than one microhm.

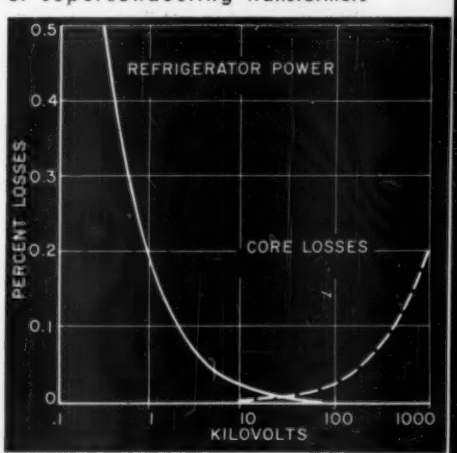
In superconducting transformers, the rating is determined largely by the voltage. As voltage is decreased, the thickness of the primary-secondary insulation can also be decreased, and the number of current carrying layers and hence the power rating increased. Figure 2 shows estimates of the relative current handling capacity of superconducting and ordinary copper transformer coils, plotted as a function of voltage. It is evident from this figure that the power handling capacity of superconducting transformers can be much greater than the conventional type of the same size. This advantage is particularly marked at the lower voltages. In making these estimates, it was assumed that the superconductors were thin tapes.

Use of tape conductors is possible because in superconductors the current is carried on the surface in a layer only a few millionths of an inch thick. An insulation strength of 300 volts per mil, comparable to the working voltages of oil-filled underground paper insulated cables, was also assumed.

High current densities in superconducting transformers with interleaved windings are not accompanied by large magnetic forces, because the magnetic fields within the coils are small, due to interleaving.

Losses in superconducting transformers must, of course, include refrigerator power input. Refrigerator

Fig. 3. These are estimated losses of superconducting transformers



power is large at low voltages because at a given power rating, low voltages mean high currents and these require heavy input leads, which produce a large heat leak. At very high voltages where large primary-secondary spacings call for large coil sizes, the core size must be increased also, and core losses eventually exceed refrigerator power. Figure 3 shows an estimate of transformer losses as a function of voltage. These losses are based on an optimum input lead design.

Figure 5 shows a sketch of a proposed superconducting transformer with supplementary equipment. This includes two low temperature refrigerators, each capable of handling the load, which together provide the high reliability needed for this application. It also includes an external air reactance, which limits the current during short circuits, to a level below the quenching point of the coils. This prevents transformer outages after short circuits which would otherwise be required to recool the windings if they were allowed to quench.

Although the transformer is operated at ten per cent of its quenching level (with 12 per cent total reactance), it is still smaller than existing types, because the maximum coil current density is many times that of conventional coils. Development of fast acting circuit breakers may obviate the need for the large derating required to surge protect the superconductors.

TRANSMISSION LINES. Consider an interleaved coaxial line, such as that shown in Fig. 4, where the conductors are lead foil layers, separated by one-tenth of an inch from one another by paper insulation, and operating at a working voltage of 300 RMS volts per mil; that is, a line voltage of 30 kv. If the mean diameter of the layers is 30 cm, and current carrying capacity of the lead is 30,000 RMS amps per meter (4.2 K), a cable with 20 conducting layers can carry a total 90,000 amps with a power rating of 2700 mva.

Although superconducting transmission lines are in theory able to carry great amounts of power, the problems involved with their use are formidable. The primary problem is the reliability of cooling needed. A line hundreds of miles long will require many cooling stations along its length. Should any of these stations fail, service will be interrupted. Even if the probability of successful operation of one station is, say 0.999 over a one-month period, the operating probability of a line with 100 such stations would be only 0.999^{100}, or 0.90, again over a month.

Other problems include the necessity for extremely good thermal insulation. At the present state of the art a heat leak (77 K to 4 K) of the order of 0.02 watts per square meter is excellent practice. A transmission line one-half meter in circumference and one hundred kilometers long using such insulation would have an over-all heat leak of one kw, requiring a helium refrigerator input of about 1000 kw. Although large, this loss nevertheless is a small part of the power which can be handled by such a line.

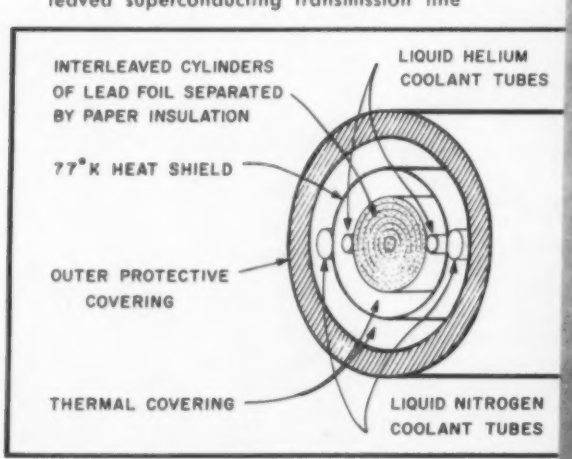
The losses involved in such a line include the extraction of heat introduced by the input leads at the ends, which at about one watt per amp, amounts to four times 90,000 watts, or about 400 kw. Heat introduced by supports will also be considerable. Dielectric losses must also be included, but they are as yet an unknown factor. It appears possible that such a line could be operated with over-all losses substantially less than one per cent of the power handled. A further advantage of such a line is that it can operate directly from the generator.

PRACTICAL PROBLEMS. Although superconducting transformers and transmission lines are unquestionably feasible and offer much in the way of low losses and small size, the practical difficulty of obtaining cooling of the very high reliability required is a serious one. Fortunately, substantial progress has been made in this area in the last few years. Some of the newer refrigerators such as that are now being developed at Arthur D. Little, Inc., which employs the new Gifford-McMahon cycle, may well by 1970 provide reliabilities approaching that of the ordinary household refrigerator.

Superconducting transformers and transmission lines will of course pose many difficult engineering problems of their own, not the least of which are purely mechanical. Nevertheless there is little doubt that such problems can be solved, and a good possibility that when this has been done, supercooled apparatus will prove more than competitive with equipment of conventional design.

A list of references by Professor McFee will be furnished on request to POWER ENGINEERING. END

Fig. 4. Cross section of possible interleaved superconducting transmission line


INTERLEAVED CYLINDERS OF LEAD FOIL SEPARATED BY PAPER INSULATION
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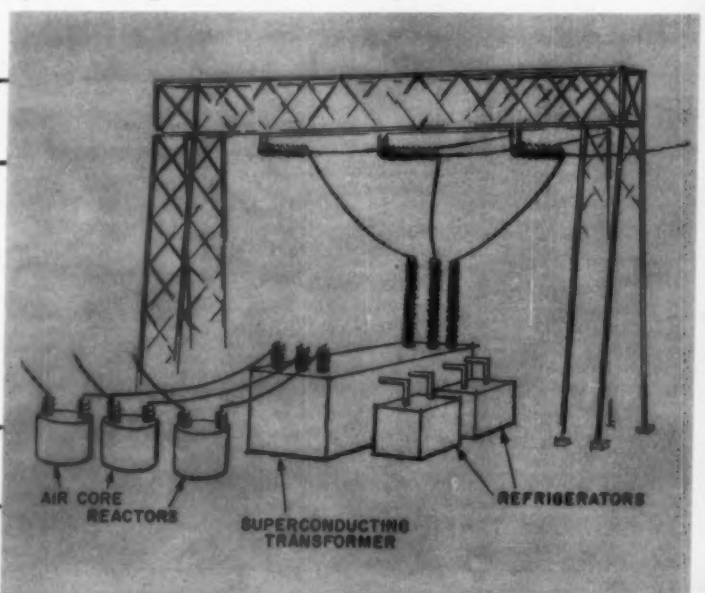
77°K HEAT SHIELD
OUTER PROTECTIVE COVERING
THERMAL COVERING
LIQUID NITROGEN COOLANT TUBES

Fig. 5. How a superconducting transformer station might look



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The passive transponder is a transmitter which has no power source of its own, but which responds by drawing power from the interrogating signal and transmits a new specific signal. This signal identifies the transponder and its exact location.

By traveling in the direction of successive transponders, the survey party can follow precisely the desired path. Various combinations of transponder signals make it possible to give exact information to the survey party. This could include such directions as: "Proceed straight;" "turn right;" "turn left;" and "danger ahead."

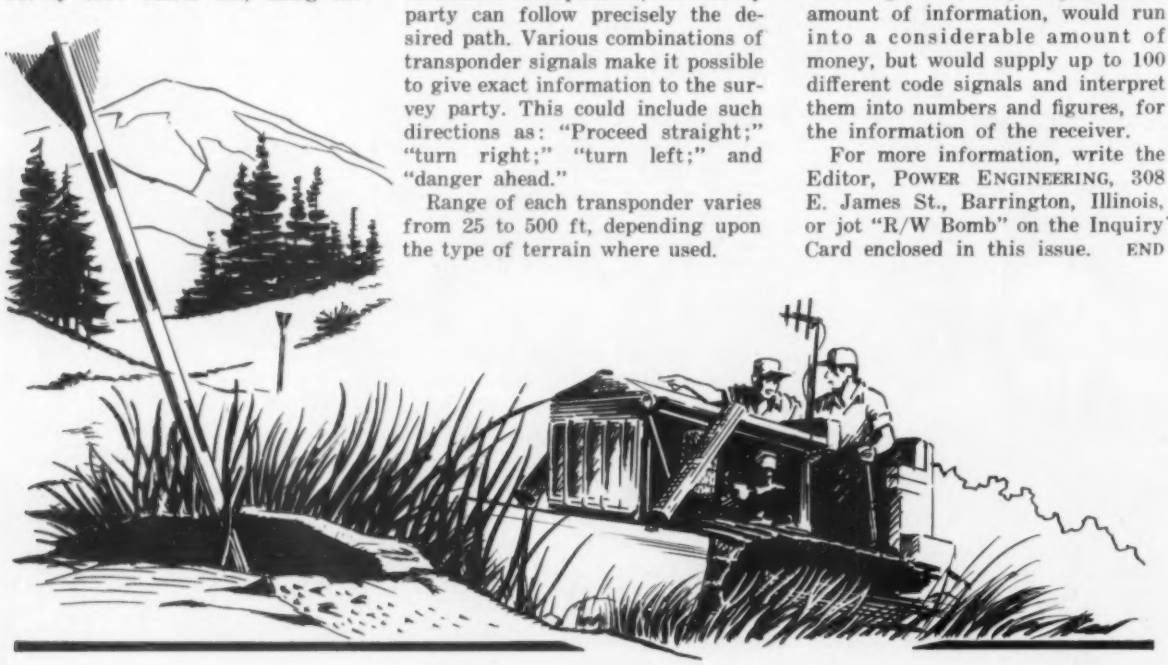
Range of each transponder varies from 25 to 500 ft, depending upon the type of terrain where used.

The transponders can be picked up by the survey party as they proceed, and used over and over again. They are completely sealed against any natural hazard; will operate at any temperature from −75 F to +170 F; are shockproof, and will not be harmed, even if they land on solid rock.

A BASIC SYSTEM, of perhaps 100 transponders and the transceiver, costs approximately $5000. Since the life of such a system is practically unlimited, the original investment could be spread over many years of use.

A more complex system, which would give a very sophisticated amount of information, would run into a considerable amount of money, but would supply up to 100 different code signals and interpret them into numbers and figures, for the information of the receiver.

For more information, write the Editor, POWER ENGINEERING, 308 E. James St., Barrington, Illinois, or jot "R/W Bomb" on the Inquiry Card enclosed in this issue. END



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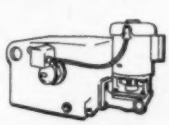

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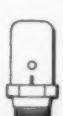

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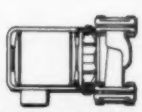

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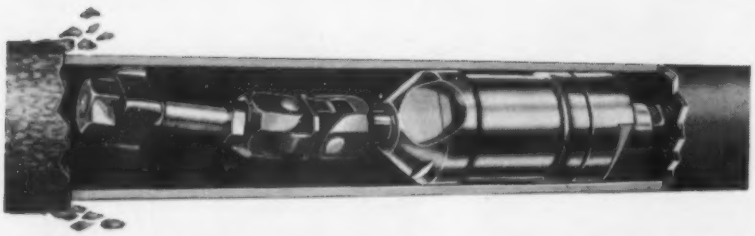

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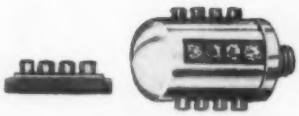

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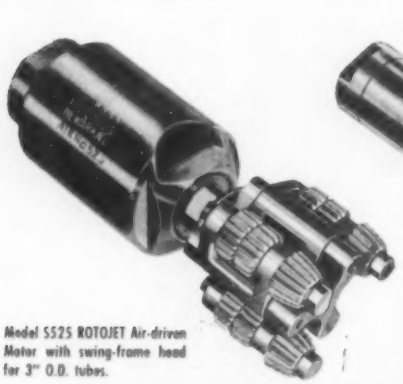

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new power construction

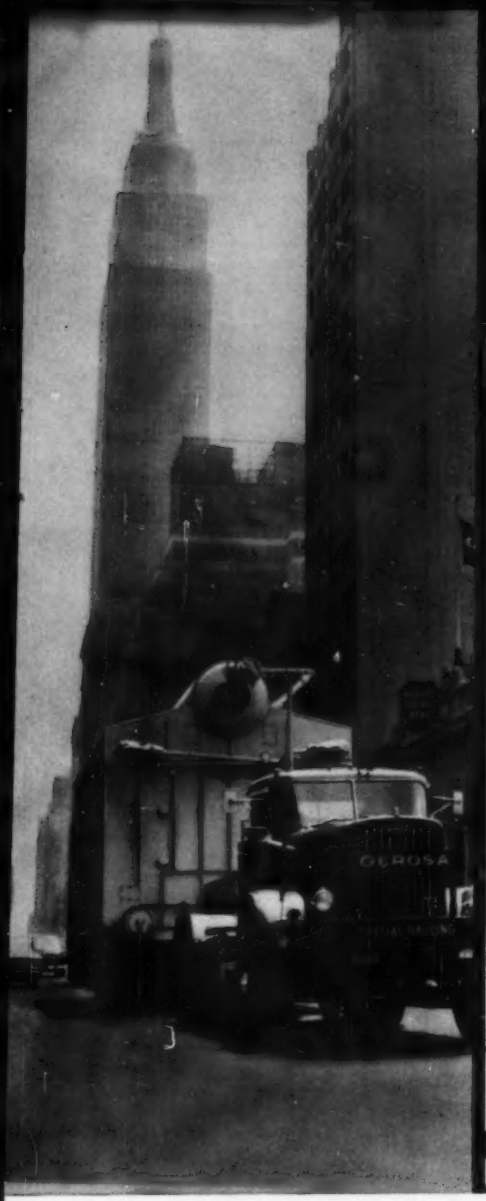
Antioch, Calif.—Pacific Gas & Electric Co., 245 Market St., San Francisco, Calif., has authorized plans for a major expansion and improvement program at its Contra Coast Power Plant located near here. Plans have been approved for the installation of a new steam-electric generating unit with a capacity of 660,000 kw, which will double present output of the plant. Preliminary work is now under way at the site, but construction on the new unit will not begin until the spring of 1962. New installation when completed in late 1964 will represent an investment of $73,000,000.

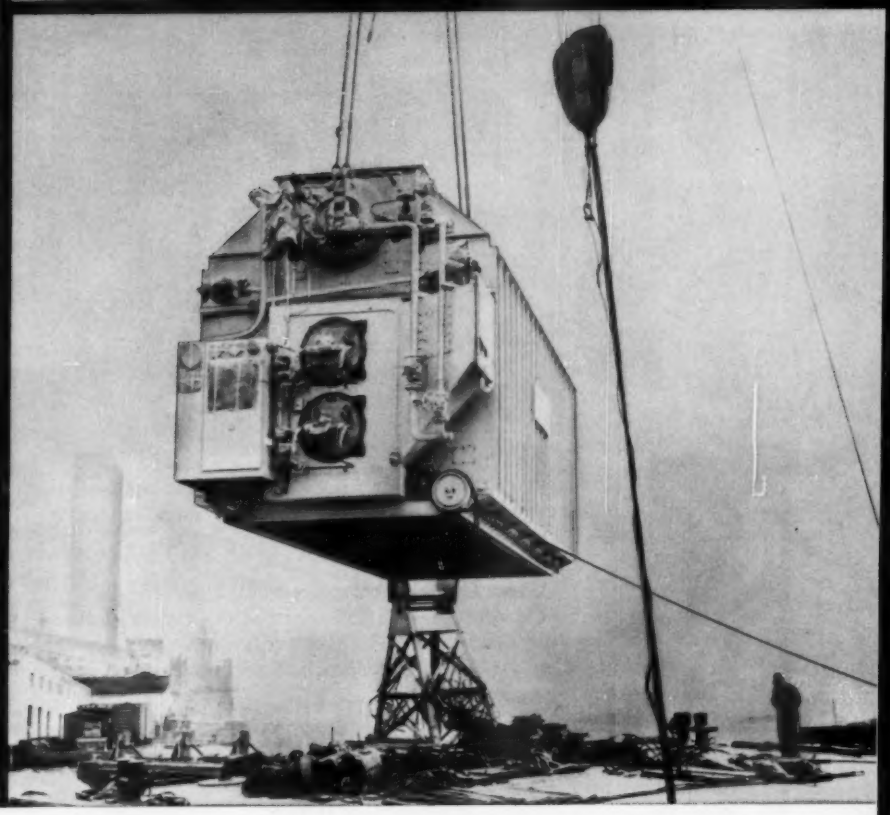
Los Alamitos, Calif.—The Los Angeles Board of Water and Power Commissioners, 311 S. Spring St., Los Angeles, Calif., has announced contract award to the Brown-Boveri Co., Baden, Switzerland, for the construction of two steam-electric turbine-generator units, each with an initial capacity of 200,000 kw, for installation at the Haynes Steam Power Plant located here. Cost of the two units will approximate $8,806,000. First of the two units is scheduled to be placed in line by early 1964.

Denver, Colo.—Public Service Company of Colorado, Denver, and Colorado Central Power Co., Golden, Colo., have announced agreement on general merger terms. Details are being ironed out after the joint announcement and will be submitted to directors of both companies. The merger must then be approved by stockholders of both companies and by the Colorado Public Utilities Commission. The agreement provides that the 3136 holders of Colorado Central common stock will receive one share of Public Service stock for each 1⅔ shares of their stock. Colorado Central serves southern and western suburban areas near Denver with power purchased from Public Service generating plants and has no generating facilities of its own.

Albany, Ga.—Georgia Power Co., 15 Forsyth St., S.W., Atlanta, Ga., has authorized plans for major expansion at its Mitchell Power Station located here. Work will begin soon on the third installation of a steam-electric generating unit with an initial capacity of 125,000 kw to triple the capacity of the plant. Plant will be completed in the third quarter of 1963 at a cost expected to reach $22,000,000. A substantial investment will also be made for continuing work on the Southern Electric Generating Company's 1,000,000 kw steam-electric generating plant near Wilsonville, Ala., which is a joint venture with Alabama Power Co., Birmingham, Ala.

Fort Wayne, Ind.—Indiana & Michi-





VIA RAIL, BARGE AND TRUCK:

two 100,000 lb/hr steam generators move into heart of New York City

En route to Pennsylvania Station South Housing Project in Manhattan, this pair of Union Type MH Packaged Steam Generators demonstrates how steam requirements (in excess of 100,000 lbs./hr.) can be fulfilled without involving field assembly.

Placed by the contractor, Raisler Corporation, the two units were shipped complete with refractories, casing, MH Firing Units, and connecting duct work. Equipped for burning No. 6 oil, each of the MH's has a capacity of 100,000 lbs./hr. at 450 psi and 600° F.

Shop assembled to standardized designs, Type MH Steam Generators and Firing Units can be supplied to handle diversified needs without costly special engineering. They can be arranged for oil or gas firing or both, with fully automatic, semi-automatic or manual control. The symmetrical, 3-drum MH design, with the top drum centered, makes it possible to ship larger units within existing rail clearances.

For detailed information, contact your local Riley Stoker Corporation or Union Iron Works office.

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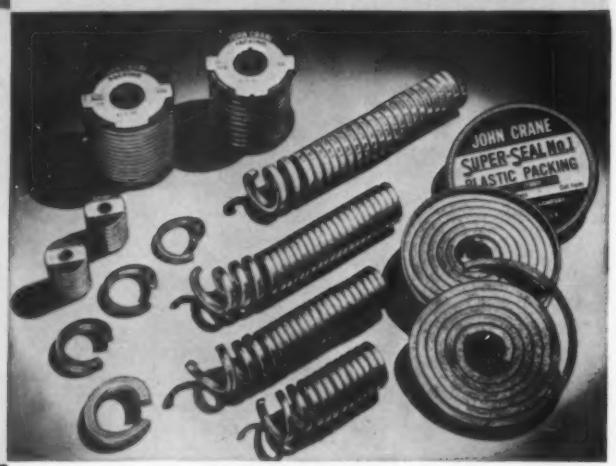

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*Du Pont trademark

CRANE PACKING COMPANY

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gan Electric Co., 2101 Soy Run Ave., this city, has authorized plans for the construction of a 186-mile, 345,000-v transmission line, including necessary substations and equipment to carry power from Tanners Creek Power Plant at Lawrenceburg, Ind., where company now has under construction a fourth steam-electric generating unit with a capacity of 580,000 kw. New installation when completed in early 1964 will cost approximately $73,000,-000. Construction of the new lines will get under way soon and will cost an estimated $12,000,000 when completed in time to take care of the increased capacity of the plant. American Electric Power Services Corp., 2 Broadway, New York, N.Y. is consulting engineer.

Baltimore, Md. — Martin Company, this city, has plans under way for the construction of a floating nuclear power plant to supply emergency electricity to military installations or port cities. The U.S. Corps of Engineers awarded the initial phase of a $16,998,-127 contract to the firm for the installation of a 10,000-kw reactor in the hull of a liberty ship. The construction, fabrication and test operations are subject to exercise of government operations and options, and the actual contract award is limited to $664,046. Design of the plant will take a little over a year, and another three years will be required for building and testing the unit, which if successful will obviate fuel supply lines necessary in present floating power plants that use diesel and steam-powered generators.

Fitchburg, Mass.—Fitchburg Paper Co., subsidiary of Decotone Products Div., this city, makers of technical and specialty grade papers for printing, packaging, office copying and similar jobs, has filed an application with the Atomic Energy Commission for permission to participate in a demonstration low-temperature processing steam-generating project utilizing a nuclear reactor. If the proposal is accepted, AEC would largely finance an indirect-cycle reactor to provide saturated steam. Fitchburg Paper Co. will use the steam for paper drying and for generating electricity for its plant. It will provide the site and facilities for using the steam and will operate the entire plant for at least a five-year period.

Rochester, Minn.—City Department of Light & Power, City Hall, Rochester, Minn., has authorized plans for a major expansion and improvement program of Silver Lake Power Plant located here. Included in the plans is the construction of a seven-story 50 by 55-ft steel frame power plant addition with installation of additional generating capacity for increased output. Preliminary work is already under way, and construction of the facility is scheduled for completion by mid-year of 1963. Cost of the program

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Nearly 50 years' experience as the leading engineers and manufacturers of gas cleaning equipment.

Hundreds of installations in various industries throughout the world, collecting dusts, fumes and mists, and cleaning gases from many sources. Here is partial list of applications.

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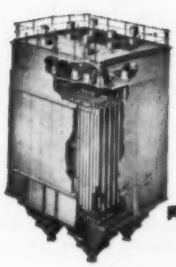

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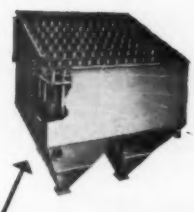
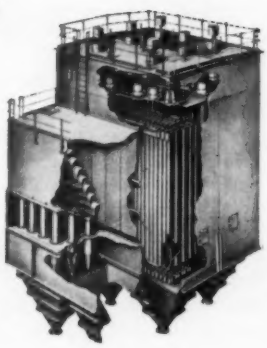
Collection efficiencies of over 99% are being obtained and guaranteed with Research-Cottrell Precipitators.

Cyclo-trell Mechanical Collectors
These low first cost high efficiency collectors provide greater separating forces and reduction in over-all resistance (pressure drop) than other types of mechanical collectors. They are available in multiple tube and involute designs.





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Custom air cleaners such as those Research-Cottrell developed for the Navy's nuclear submarines are available for special applications.

Flooded Disc Scrubber
Adjustable—High efficiency. No increase in pressure drop, even at gas flows 50% over normal. No nozzles to wear or plug up.

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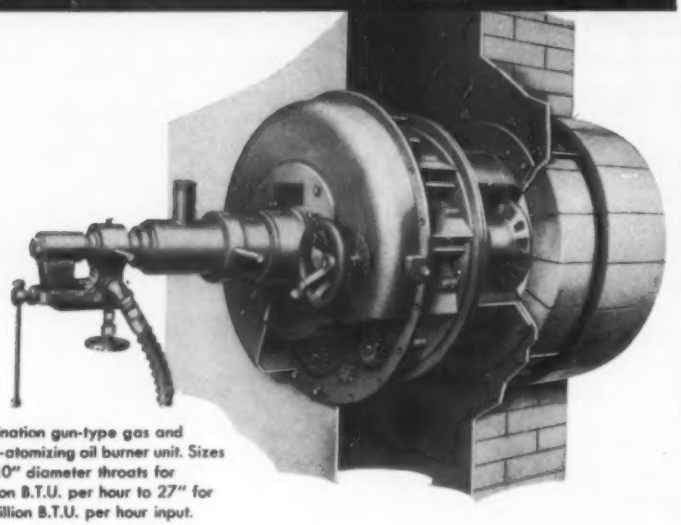
TYPE E OIL BURNER UNIT



Combination gun-type gas and steam-atomizing oil burner unit. Sizes from 10" diameter throats for 7 million B.T.U. per hour to 27" for 100 million B.T.U. per hour input.

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1. Vanes can't stick—Easily adjusted

Air register vanes are easily adjusted by a single hand wheel for either clockwise or counter-clockwise air rotation. The action is without stiffness or sticking. Vane shafts are stainless steel — heat-resistant, corrosion-proof — turn smoothly in carbon graphite bearings at all operating temperatures.

2. Positive Vane Control —no lost motion

Chain-and-sprocket air-vane control, with take-up adjustments, assures easy and precise setting at all times. There are no links to wear and wobble with a flopping action of the vanes when they pass dead center.

3. Adaptable to oil or gas —or both

Changeover from oil to gas or a combination of both can be done easily — with comparatively low cost standardized parts—to get the full advantage of variations in fuel prices.

4. For wide range or standard range burners

Registers accommodate standard range or wide range oil burners — mechanical or steam atomizing — and gun type or ring type gas burners—the one best type or combination for your individual needs.

5. Adaptable to all housing designs

Extra deep burner housing can be used to suit practically any fan and any duct arrangement — with lowest installation cost — and provide proper air distribution for efficient combustion.

Bulletin G59 gladly sent on request

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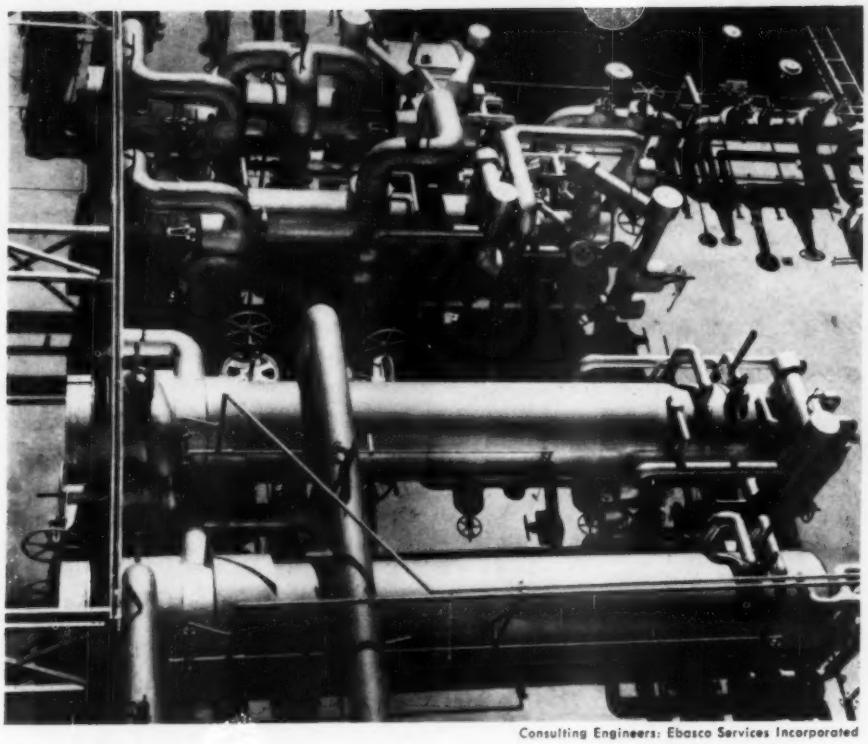
with equipment is estimated at approximately $1,000,000. Pfeifer & Shultz Co., Wesley Temple Building, Minneapolis, Minn., is the consulting engineer.

Blairstown Township, N.J.—Jersey Central Power & Light Co., 501 Grand Ave., Asbury Park, N.J., has notified the Federal Power Commission of its intention to build a 300,000-kw hydroelectric plant on a large site here, recently acquired for the purpose. The project will utilize an upper reservoir atop Kittatinny Mountain and a lower reservoir on Yards Creek each with a storage capacity of more than a billion gallons of water. Public Service Electric & Gas Co., 80 Park Place, Newark, N.J., will participate in the project. Company will be interconnected with Jersey Central so that a proportion of the output produced by the plant would be made available to its customers. Construction will proceed at once subject to regulatory approvals from the State, with completion scheduled for early 1964.

Jersey City, N.J. — Public Service Electric & Gas Co., 80 Park Place, Newark, N.J., has authorized contract award in the amount of $12,000,000 to the Babcock & Wilcox Co., Inc., 161 E. 42nd St., New York, N.Y., for the installation of high-pressure boilers and related equipment at company's new power station now under construction at this place. Boiler will be installed in conjunction with a new 342,000-kw turbine-generator which is scheduled for completion early in 1965. At full load the boiler will consume about 3000 tons of coal per day. Provision is being made for the future firing of the boiler with fuel oil. New installation will be of an advanced type that burns fuel at high temperatures and pressures for economical production of power.

Fruitland, N.M. — Arizona Public Service Co., 501 S. Third St., Phoenix, has announced that construction is under way on a thermal-electric generating station on a Navajo Indian Reservation here. Plant will have an initial capacity of 350,000 kw and will be known as the Four Corners Power Plant. Contract has been let to the Ebasco Services Co., Inc., of New York, N.Y., for the work which will be completed in the early part of 1964 at a cost to Arizona Public Service of some $62,000,000. Utah Mining & Construction Co. will supply fuel from 24,000 acres of undeveloped tribal lands and provide a 1200-acre cooling water reservoir on the building site of 1250 acres.

Blackwell, Okla.—City Department of Power & Light, City Hall, has approved plans for proposed expansion and alterations in the municipal power plant including installations for increased capacity. Work will proceed at once on plant additions which are



Consulting Engineers: Ebasco Services Incorporated

4,000 PSI 1,000°F (OR EVEN HIGHER WHEN YOU NEED IT!)

FEEDWATER HEATERS WITH YUBA'S EXCLUSIVE MULTILOK CLOSURE are capable in basic design of operating at the extreme pressures and temperatures required more and more by the power industry.

The Multilok Closure, a Yuba exclusive, is one of the important reasons why these units operate so efficiently and safely in the 4,000 PSI, 1,000° F range. And Yuba is prepared to produce units to handle even higher pressures and temperatures when needed. A pioneer in all-welded design, Yuba offers both all-welded and bolted construction – a complete and versatile line of feedwater heaters tor high and low ranges, for every type of job. When space is a critical factor, as many as three low pressure stages can be combined in a single shell for a highly compact unit.

You'll want to discuss both design requirements and costs with Yuba heat transfer engineers during plant planning stages. The scope of Yuba designs will offer the best solution to your particular problem.

Other Yuba products for steam power plants include condensers, evaporators, expansion joints, tanks, bridge and gantry cranes, structural steel erection, and scores of other items.

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YUBA HEAT TRANSFER CORPORATION
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two new INTERCHANGEABLE trays for support of cables, wiring and tubing

★ Engineered for uniform design and easy installation
★ Steel or aluminum construction
★ Complete accessories for SPEEDIER installation
★ No sharp edges to damage cables
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Now, for the first time, two types of cable trays, one a ladder type and the other a basket type, are available to be used INTERCHANGEABLY at any given location, depending on the type and weight of the cables to be suspended. The advantages of each type tray can thus be used to the fullest extent. Globetray, the ladder type, is intended for use where festooning is not a problem, while Cable-Strut, the basket type, is intended for the support of communication wire, instrument tubing and control cables in automation applications.

These two cable trays have been thoroughly field tested in hundreds of large industrial installations, in new plant construction, in power plants, in modernization, and for power distribution in all types of manufacturing processes. A new catalog, just off the press, gives full information and installation techniques. Ask for your FREE copy today.

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scheduled for completion by the summer of 1962 at a reported cost of $500,000. A bond issue to cover the cost of the work has been authorized.

Oklahoma City, Okla. — Oklahoma Gas & Electric Co., 321 N. Harvey St., has announced that a group of investor-owned utilities, including themselves, plans to construct a 4000-mile network of extra-high-voltage transmission lines linking an eight-state area in the Southwest, that would interconnect power systems in Arkansas, Kansas, Louisiana, Mississippi, Missouri, Nebraska, Oklahoma and Texas. The grid will cost more than $300,000,000 and will be designed for initial operation at 345,000 volts, with provision for possible enlargement to 500,000 volts when needed. Oklahoma Gas & Electric plans to begin construction soon of the initial 30-mile section of the line.

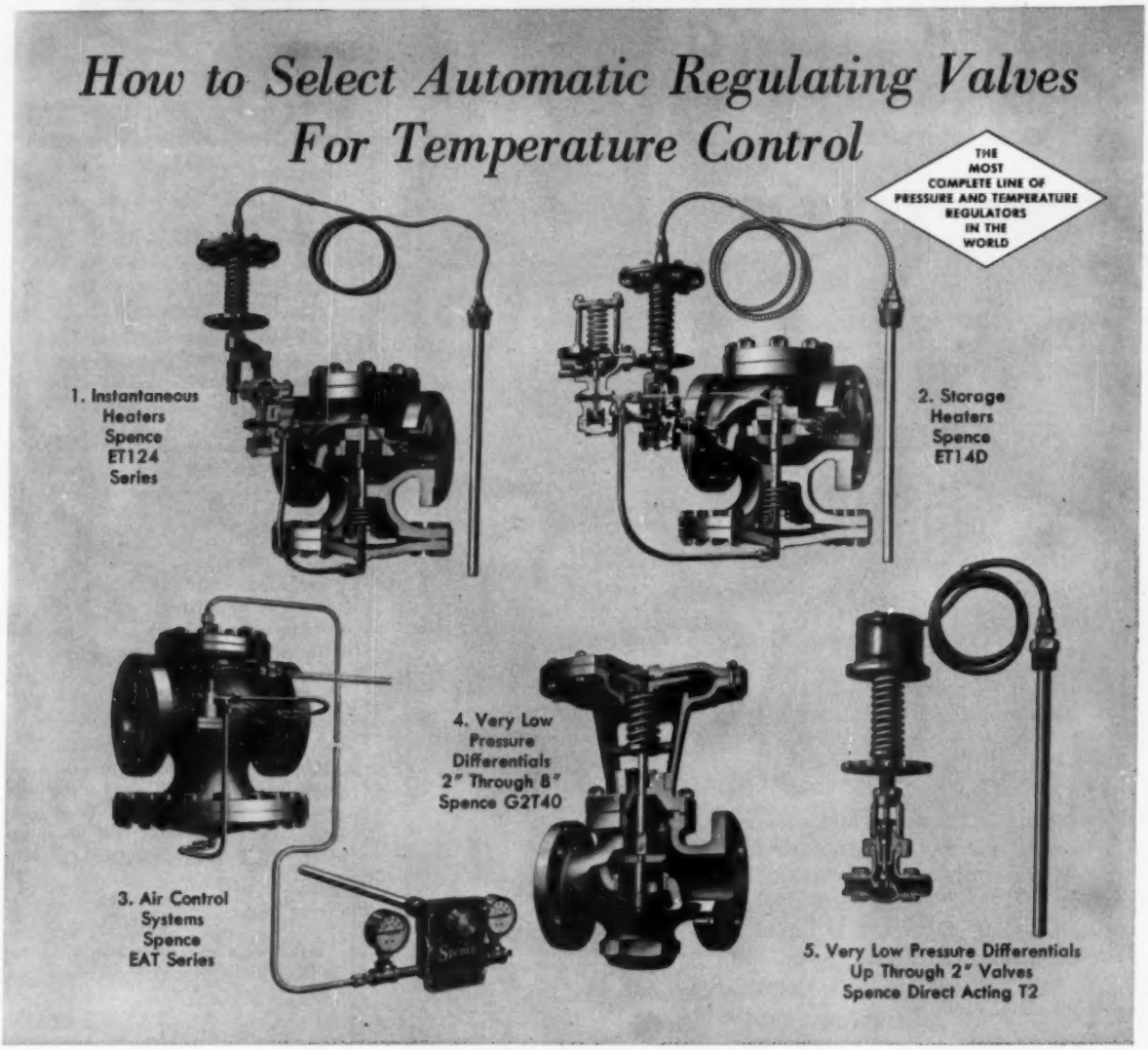
Oahe, S. D.—Bureau of Reclamation, Department of the Interior Building, 1A, Denver Federal Center, Denver, Colo., has authorized contract award to the Midland Constructors, Inc., 222 W. Adams St., Chicago, Ill., for laying foundations and erecting steel towers for a proposed single circuit transmission line approach to Oahe and Fort Randolph switchyards. Work on the project has already begun and is scheduled to be completed by the fourth quarter of 1962. Cost of the work is reported to be $331,600.

Oak Ridge, Tenn.—The Atomic Energy Commission, 1901 Constitution Ave., N.W., Washington, D.C., has announced contract award in the amount of $6,000,000 to the H. K. Ferguson Co., Cleveland, O., for construction of an isotope production reactor at its Oak Ridge national laboratory. Company received the basic construction contract, a substantial part of which will be performed under fixed-price contracts and purchase orders. Total cost of the installation, scheduled for completion by 1964, will be approximately $12,000,000. Commission also announced award of a $341,570 contract to Allis-Chalmers Mfg. Co., Milwaukee, Wis., for the construction of a pressure vessel for the reactor.

Hanford, Wash.—The Atomic Energy Commission, 1901 Constitution Ave., N.W., Washington, D.C., through the Hanford Operations office has announced that plans to construct the world's largest atomic power plant at this site, by converting a plutonium-producing reactor to generate 700,000 kilowatts of electricity have been abandoned for the present. As previously announced in these columns, the Kennedy Administration had planned to turn the local reactor into a dual purpose plant producing plutonium for atomic weapons and generating electricity for consumers in the Pacific Northwest. The reactor already under construction is scheduled to be completed by the fourth quarter of 1962.

VALVE TIPS:

How to Select Automatic Regulating Valves For Temperature Control


THE MOST COMPLETE LINE OF PRESSURE AND TEMPERATURE REGULATORS IN THE WORLD
1. Instantaneous Heaters Spence ET124 Series
2. Storage Heaters Spence ET14D
3. Air Control Systems Spence EAT Series
4. Very Low Pressure Differentials 2" Through 8" Spence G2T40
5. Very Low Pressure Differentials Up Through 2" Valves Spence Direct Acting T2

During the past year, our field representatives have reported many cases of improperly, and uneconomically, applied temperature regulators. To help you avoid some of these costly mistakes, here are a few tips on selecting the most effective and economical temperature regulating valves for your applications.

1. Instantaneous heaters require a special action for close temperature control and freedom from hunting. In the Spence ET124 series, steam pressure is modulated according to temperature (demand) and is automatically regulated at any pressure established by the demand.
2. Storage heaters, on the other hand, are more economically controlled by the Spence ET14D, which includes a simple temperature-actuated pilot that opens and closes the main valve to maintain a constant temperature.
3. Air control systems can now have a ±5°F control accuracy under wide and instantaneous load swings with the Spence EAT regulator. Engineers report savings of up to 50% in installed costs with this recently developed Spence cascade system when it has been used in place of conventional instrumentation.
4. For the combination of very low pressure differentials and air or water control, Spence recommends Type G2T40. This single seated valve provides fast, positive response in 2" through 8" valves. Double seat Type G22 is also available in 10" through 12".

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5. When very low pressure differential is encountered with valves of 2" or less, the Spence direct operated T2 is recommended. The sensitive vapor tension thermostat responds quickly to small changes in bulb temperature for continuous, accurate control.

In this brief description of industrial process and heating temperature control, we have given a few important tips in proper regulator selection. If you would like more detailed information on these control applications, write for the new Spence Temperature Control Bulletin IV 1014. BE-180

SPENCE ENGINEERING COMPANY, INC.
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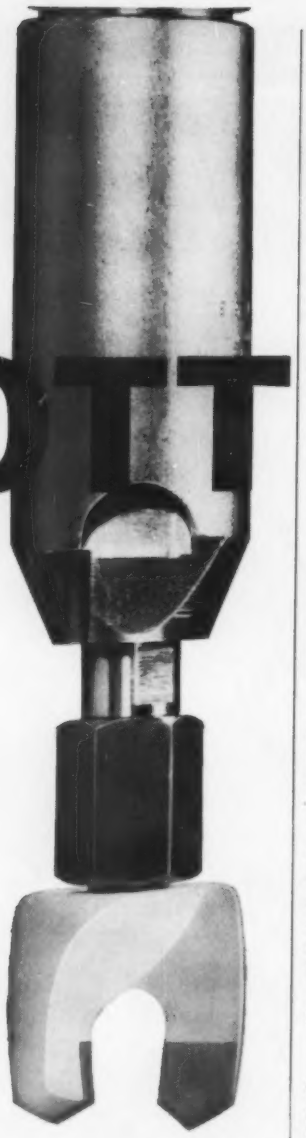
to clean badly clogged air preheater tubes

ELLIOTT

heavy duty tube cleaner



Shown above is the powerful Lagonda heavy-duty air motor with carbide-tipped cutter bit. Attached to a flexible air hose, this unit can operate in any position where headroom is limited. The carbide tip will clean even the most badly clogged tubes, quickly and effectively.

Where headroom permits, the heavy-duty suspended-type motor shown at the right can be used to drive a cutting bit attached to a hollow steel shaft, through which flushing and cooling water is fed. This extremely powerful unit can be used either vertically or horizontally.

Full information and prices may be obtained from any Elliott District Sales Office, or by writing Elliott Company, Lagonda Plant, Springfield, Ohio.

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new engineering books

Electrical Estimating, third edition, by Ray Ashley; 225 pages, 7¼ by 9⅞ in., cloth bound. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. Price $12.50.

This book is aimed at the electrical contractor and estimator, and is full of practical methods, tips and guides which will help him to streamline his estimating procedures.

The book ranges in coverage from selection and training of electrical estimators and proper use of estimating tools, to the cost of preliminary estimates and preparation of final bid sheets.

Included are 25 tables of labor-cost units, embracing over 1800 individual items. There are guides for estimating and billing job costs; other curves and tables indicate how to figure overhead in accordance with the size of the project and its duration, and how to estimate the cost of extended duration. There are special sections on installation-only projects, and five complete sample estimates taking the reader step-by-step through typical jobs.

Ray Ashley is an electrical engineer and estimating consultant.

Handbook of Instrumentation and Control, by Howard P. Kallen; 692 pages, 6¼ by 9¼ in., 550 illustrations, cloth bound. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y. Price $15.

This is a practical manual for the mechanical services, covering steam plants, power plants, heating systems, air-conditioning systems, ventilation systems, diesel plants, refrigeration and water treatment.

In treating instrumentation for pressure, temperature, flow, liquid level, pH and conductivity, combustion and boiler controls, the needs of the engineer who designs and develops instruments, as well as the application engineer, were kept in mind.

Numerous clear illustrations, tables, charts and graphs add measurably to the value of the book. Typical practical applications of all controls are described, as are newer developments such as control sys-

ILLCO-WAY ion Exchange

A DISCUSSION OF COUNTERFLOW* REGENERATION

THIS PATENTED METHOD PROVIDES MORE EFFICIENT OPERATION OF ION-EXCHANGE EQUIPMENT.

Conventionally, in ion-exchange equipment used for chemical processes, the resin bed is exhausted, or "loaded," by a downward flow of liquid and then regenerated, or "stripped," by a *downward* flow of acid or alkali.

As a result, the lower part of the resin bed is inadequately regenerated, unless a great excess of regenerant is used. Then, during the service cycle, the impurities thus left near the bottom of the resin bed will be leached off into the product. Or, if the resin is used to pick up valuable materials, an incomplete separation will occur.

The logical solution would be *up-flow* regeneration, but normally, due to the low density of ion-exchange resins, the bed would rise or expand and there would be insufficient contact of regenerant. With COUNTERFLOW*, however, Illinois Water Treatment Company has achieved successful *up-flow* regeneration by introducing a "barrier" to prevent bed expansion. For example, one method is to introduce water at the top and regenerant at the bottom, drawing both off just above the resin bed.

Substantial improvements result from COUNTERFLOW* — resin capacity increased as much as 25%, leakage of impurities reduced as much as 75%. Where the resin is used to pick up valuable materials, COUNTERFLOW* "stripping" gives more complete separation without increased dilution.

***COUNTERFLOW** is the trademark of Illinois Water Treatment Company equipment utilizing an up-flow method of regeneration with a "barrier" to keep the bed from expanding. U.S. Patent No. 2,891,007.*

For detailed information, address:

ILLINOIS WATER TREATMENT CO.
840 CEDAR ST., ROCKFORD, ILLINOIS
NEW YORK OFFICE: 141 E. 44th St., New York 17, N.Y.
CANADIAN DIST.: Pumps & Softeners, Ltd., London, Can.

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5. 180° Visibility!
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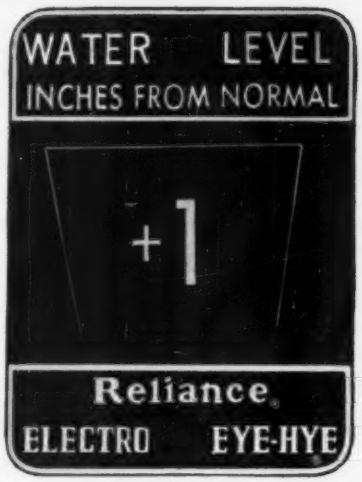

Choose either the exclusive Reliance Digital Readout (2 sizes) that shows water level with big illuminated numerals

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Use a Reliance Ten-Light indicator (3 sizes) with bright red lenses visible from any angle.

Now you can have unparalleled accuracy, simplicity and safety in a remote water level indicator with the new Reliance Electro EYE-HYE. All liquid connections are right at the boiler . . . no need for long pressure lines or compensating devices of any kind. One Electro EYE-HYE measures any variation in height you desire . . . can operate auxiliary alarms and/or fuel cutouts.

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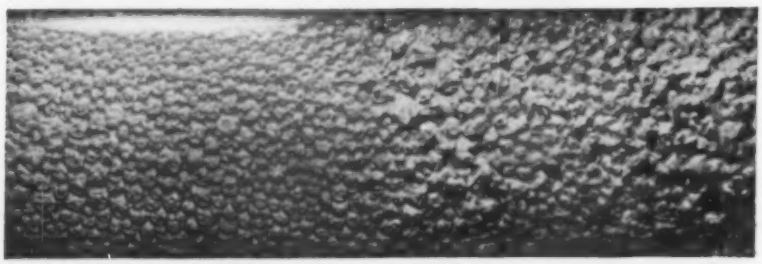
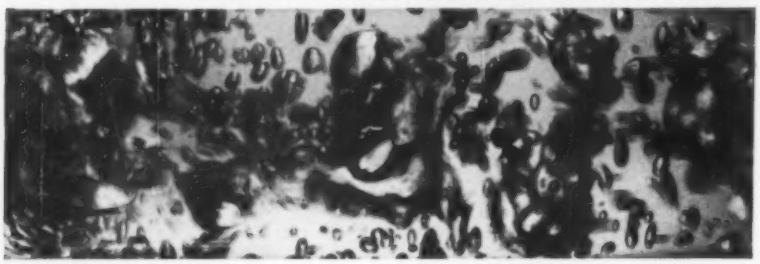
CARRYOVER



Foam build-up in untreated boiler water

No foam in boiler water treated with Concentrol



MUST BE STOPPED!

Carryover of solids due to foaming is in most cases continuous. Suspended matter helps the foam layer build up so that steam bubbles, with their entrained boiler water, do not break quickly at the steam-water interface. Thus, boiler water is carried over into the steam mains.

Many plants with wet steam problems have determined that carryover must be stopped and have turned to the Bird-Archer Company for an economical solution. Bird-Archer research in stabilizing boiler water with high foam potential is backed by 60 years experience. The result is the development of a highly effective antifoam agent called CONCENTROL. Even when used in relatively small dosages Concentrol is effective in combining both resistance to hydrolysis or breakdown under boiler temperatures and pressures with ability to control foam.

Write for Bulletin on "Concentrol", and name of the Bird-Archer Service Engineer nearest you.

BA102

LABORATORIES · ENGINEERS · CHEMISTS

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WATER TREATING CONSULTANTS

The BIRD-ARCHER Company, 4337 N. American St., Phila. 40, Pa. / New York • Chicago

The BIRD-ARCHER CO. of California, 415 Brannan St., San Francisco • Offices in Canada and Mexico

For more data circle 549 on Post Card

tems for high-pressure steam plants and controls for large central air-conditioning systems found in office buildings, hospitals, schools, and other commercial and institutional buildings.

From basic facts on instruments to thorough descriptions of complete control systems, this guide places at your fingertips vital information needed to procure, specify, or design equipment. The book is highly recommended.

Magnetic Control of Industrial Motors, Part I: A-C Control Devices and Assemblies, by Gerhart W. Heumann; 273 Pages, 6 by 9¼ in., cloth bound. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. Price $9.

This is volume I of a three-volume set which is based on the author's previous book of the same name. Material in Part I covers essentially the same things as chapters 1, 5, 6, 7, 8, 9, 10, 15 and 20 in the previous book. New material reflects recent changes in the design of control devices and equipments.

Primarily an application book, controllers for industrial type motors are carefully analyzed, and each type of motor is fully treated in conjunction with its associated controllers.

Each chapter closes with a bibliography listing books, papers and articles which are obtainable from reference libraries. Entries were selected for their practical application rather than for mathematical or highly technical analysis. Practical problems are listed at the end of chapters suited for problem work.

Thermodynamics, by Francis W. Sears; 374 pages, 6⅛ by 9¼ in., cloth bound. Published by Addison-Wesley Publishing Co., Inc., Reading, Mass. Price $9.75.

Full title of this book is An Introduction to Thermodynamics, The Kinetic Theory of Gases, and Statistical Mechanics.

F. W. Sears is a distinguished professor of physics, and his text is a rigorous treatment of thermodynamics from the viewpoint of a physicist. The book is very clearly written, and is recommended to the engineer who wishes to supplement his more practical training in thermodynamics with a firm grounding in physics.

A good selection of problems appears after each chapter, and answers are at the back of the book.

THE LONERGAN LINE

HOW TO MAKE A GOOD IDEA BETTER

by Norman J. Smith

In this hurry-up age of missiles and electronics, it is often possible to overlook the fact that because a device or an idea is new, it is not necessarily the best.

For example, while there are many temperature and pressure sensing devices, none

has such universal application as the Bourdon tube, which was first conceived in 1849 by a French engineer, Eugene Bourdon.

Today, a modern "C" type Bourdon tube gauge, such as the Lonergan Maximon makes full use of Bourdon's original idea. At the same time, it utilizes the finest materials such as K Monel stainless steel, beryllium, copper and many, many others in order to improve Bourdon's basic invention. Other improvements are: twisted spiral tubes to measure the output of pressure transducers; long helical tubes with heavy walls to measure pressures up to 100,000 psi; and small tightly coiled tubes for movementless gauges.

While the power plant man with a gauge problem isn't concerned with all of these forms, it is interesting to note that in his application for a patent more than a hundred years ago, Bourdon anticipated all of these present day variations. He claimed application on all forms of curved or twisted tubes whose transverse sections differed from circular forms for temperature and pressure measuring, indicating and controlling of fluids.

The Lonergan gauge today incorporates all of the known advances in the Bourdon tube in any one of three lines. For applications requiring the finest gauge available anywhere, the Lonergan Maximon is the choice.

Get a full description of the complete line of Lonergan gauges in catalog 1000-G. *Write for your copy today.*

Norman J. Smith

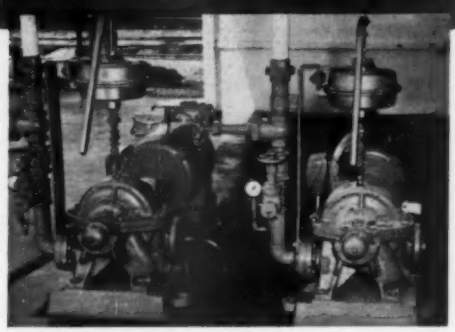
Chief Engineer, Instrument Division

Lonergan

J. E. LONERGAN CO., 207 RACE STREET
PHILADELPHIA 6, PA. SINCE 1872

For more data circle 550 on Post Card

all the water needed with 7 WEINMAN PUMPS



Two of the seven Weinman Pumps aboard the Clark Marine Corporation's new barge cleaner, **Jane K. Clark.** Built by Equitable Equipment Company, the welded steel 100′ x 36′ x 8′ barge is the only one of its kind operating on the Mississippi River.

When you need large quantities of water wherever you go, how do you get it? The Clark Marine Corporation, Baton Rouge, Louisiana, found the answer in the seven Weinman Pumps installed on their new floating barge cleaner, the *Jane K. Clark*. One of the most modern and efficient ship and barge cleaning plants in the United States, it is unique on the Mississippi River because it can carry out cleaning and de-sludging operation in mid-stream.

As a completely self-contained plant, the barge needs large quantities of clean water for its operation. Equipment aboard includes steam plant, water purification plant, 3 water filters and 2 water softeners for removing impurities from the river water. In addition, boiler feed water requires special treatment.

For quick, efficient water circulation to and from each of these operations, the *Jane K. Clark* depends on Weinman . . . and 7 Weinman Pumps deliver the water with speed and economy where it's needed . . . when it's needed.

So, if you have a pumping problem . . . no matter how unusual . . . there's a Weinman Pump to solve it. Consult your Weinman Centrifugal Specialist today . . . you'll find him in the Yellow Pages. Or, write direct to . . .

THE WEINMAN PUMP MFG CO.
290 SPRUCE STREET COLUMBUS 15, OHIO
CENTRIFUGAL SPECIALISTS

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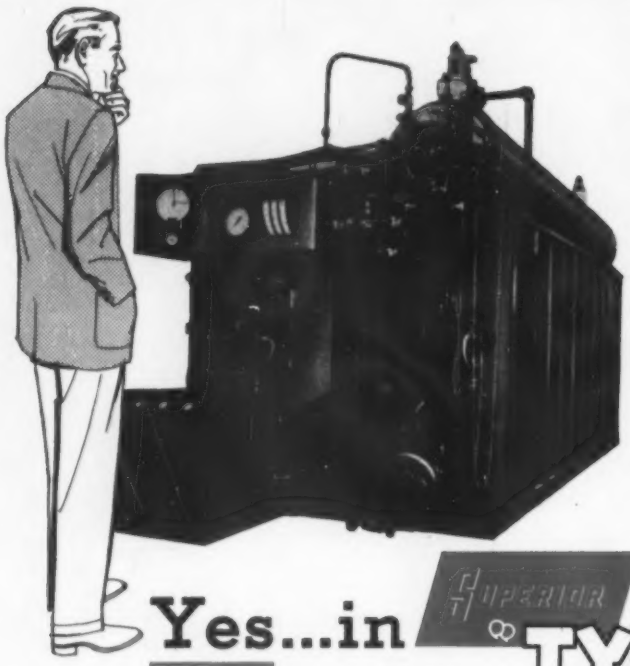
are the Tube-Holes Serrated?



Ask this question before you buy a water-tube boiler. It is of vital importance in providing protection against caustic embrittlement.

Ask this question of Superior's Type D Completely Packaged Boiler and you'll find that . . .

Yes...in Superior Type D they are!

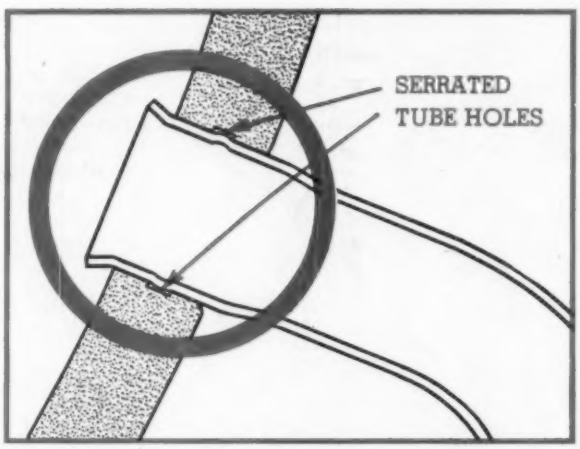
While more positive boiler-fabricating techniques and improved methods of boiler-water treatment have alleviated the problem of caustic embrittlement in water-tube boilers, it is still a serious problem.

Realizing that caustic embrittlement is a problem, Superior Combustion Industries has designed its Type D Boiler with serrated tube-holes . . . a feature (see illustration) which guards against tube-leakage, one of the prime factors contributing to embrittlement.

Another feature (not illustrated) of Superior's Type D is its simple tube arrangement. Free of double tube-bends, Superior's water-tubes are far less susceptible to excessive scale formation. And . . . with every tube completely drainable by gravity, no extra blowing operation is required for cleaning.

Fired by Gas, Oil or Both, the Type D is of course a Complete Package, designed for capacities from 11,000 to 72,000 lbs. of steam per hr.

For condensed data describing the World's Most Complete Line of Packaged Boilers write today for Catalog S-12.



In this cross-sectional drawing of Superior's serrated tube-hole, you can see how rolled joint is made stronger by expanding the tube into the serration.

Fire-Tube and Water-Tube PACKAGED BOILERS

for STEAM or HOT WATER

SUPERIOR COMBUSTION INDUSTRIES INC.

TIMES TOWER, TIMES SQUARE, NEW YORK 36, N. Y.

SUPERIOR PACKAGED BOILERS

For more data circle 552 on Post Card

Current Catalogs

continued from page 32

Pumps, Compressors

150 **Pump Fundamentals** — A non-technical, elementary outline of the characteristics, operation and selection of reciprocating, rotary and centrifugal pumps is contained in 16-pp Form 5773J, by Goulds Pumps Inc. Includes definitions, basic formulae and application data.

151 **Pump for Problem Liquids** — Design and construction features of the Electri-Cand, a sealless, leakless pump for safe handling of problem liquids, are presented by Allis-Chalmers Mfg. Co. in Bulletin 52B8471B. Lists typical solutions handled by the pumps in various fields. Capacities, heads, pressures, temperatures and horsepower ratings given.

152 **Lined Centrifugal Pumps**— Pumps for corrosive service, their performance curves and other technical data, are described in 8-pp Bulletin 301 by Industrial Filter & Pump Mfg. Co.

153 **Engines, Compressors, Turbines** —The Cooper-Bessemer Corp. line of engine and motor driven compressors, power and expansion engines, jet-powered gas turbines and En-Tronic Control systems is presented in 14-pp Bulletin 100, covering specifications, features and applications of each model in the line.

Materials Handling

154 **Vibrating Conveyors**—Natural frequency vibrating conveyors with variable stroke positive drive are detailed in Bulletin 361 by Stephens-Adamson Mfg. Co. Charts show trough dimensions, and models' tons-per-hour capacity for lumpy, bulky and fine materials.

155 **Wire Rope Conveyors**—Bulletin 173, 24 pp, describes Hewitt-Robins wire rope conveyors, above and below ground. Fully illustrated with sketches and product photos, presents advantages of the conveyors, basic types of head sections, electricals, power units, idlers, wire rope supports, belt take-ups, auxiliary equipment and new conveyor components.

Insulation, Firebrick

156 **Insulating Firebrick**—Advantages, applications, and constructions of insulating firebrick are detailed in 36-pp Bulletin R-38 by the Babcock & Wilcox Co. Also provides selection data and illustrates use in power plants as well as metals, ceramics, chemical and petrochmeical industries.

157 **Insulating, Finishing Materials** —Clute Cotes, a series of five insulating and finishing asbestos cements, are described in this bulletin of The Clute

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Corp. Gives specifications, features and application suggestions for each product in the line.

Other Equipment

158 Pipe Tools — Hand tools for pipe, tubing and conduit are illustrated in Reed Mfg. Co.'s 16-pp catalog. Technical data includes cutter wheel reference chart, tables of solid and adjustable pipe and bolt dies.

159 Ventilating Heaters—Featured in this 10-pp product bulletin by Morrison-Pelsue Co. are ventilating heaters used by utilities for bringing fresh heated air into underground areas. Principle of operation discussed and specifications included.

160 Sealing Components — Colorful 16-pp Catalog 359B shows A. P. M. Corp.'s line of high pressure seals and fasteners, transparent, flexible seals, and other products. Dimensional drawings, specifications, technical and ordering data given.

161 On Silicone Fluids—Twenty-pp Technical Data Book S-9 is offered by General Electric Co. as a technical reference on silicone fluids. Differentiates between available grades according to viscosity and classifies them on basis of physical properties. Provides physical data summary chart and silicone fluid selector in which available grades are identified by application areas.

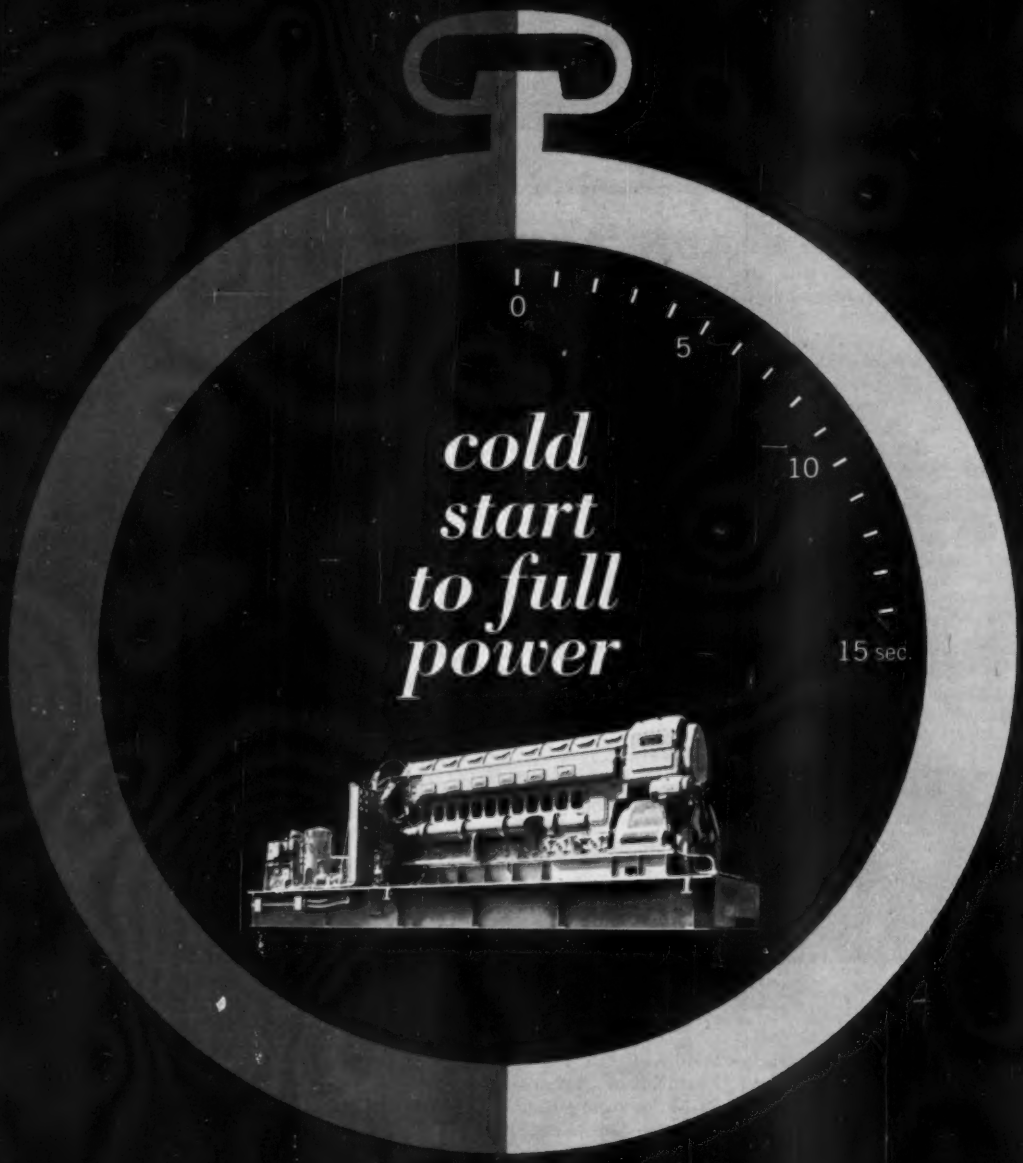
162 TV-Interference Prevention — An electrical bonding brush for eliminating arcing due to corrosion of metal parts is illustrated and described in bulletin by Erie Fan & Blower Co., Inc. Includes a report on a study made for a utility company. Field procedure for locating and correcting condition is given, installation tools shown.

163 Surface Dehumidifiers — Bulletin SCD-1, 8 pp, by Blazer Corp., covers a line of sectionalized spray coil surface dehumidifiers in sizes to 50,000 cfm. Construction features are detailed, dimensions and weights tabulated.

164 Compression Tube Fittings — Twenty-page Catalog 4323, by Parker Fittings & Hose Div., Parker-Hannifin Corp., describes Ridg-lok fittings with reversible ferrule feature. Includes ordering and assembling data, tabulations of size and pressure, and cross-section views of application.

165 Vacuum Stills — Bulletin FB-101 by Hoffman Industries Inc., describes vacuum stills designed to reclaim contaminated solvents and condition them to new solvent specifications at minimal cost. Describes operation and includes specifications.

166 Fuel Oil Heaters for Heavy Liquids—Brown Fintube Co., in Bulletin 200, 8 pp, describes an improved line of fuel oil heaters for heating viscous fluids—Bunker Coils, asphalts, molasses etc. Two types are described —a tank suction heater, and a line type heater. Technical data given.



...15 seconds with Fairbanks-Morse Diesels

The F-M 38D8⅛ Opposed-Piston Diesel Generating Unit—with only 15 seconds *from cold start* to full power—gives fast, sure power for peaking or for standby use, together with impressive operating economies.

This unit requires no spinning reserve . . . uses no power until it starts, then produces up to 2500 kw per unit. Can be linked in multiple units.

Dependable? Service records of F-M Diesels prove dependability beyond a doubt (F-M pioneered the manufacture of diesels in America . . . has kept in the forefront ever since.)

Economical? The 38D8⅛ has 40% fewer moving parts than comparable engines of equal horsepower. This means reduced maintenance costs . . . fuel and lube oil savings.

Opposed-piston design minimizes vibration, produces fine balance . . . smooth power and instant response that result in 15 second full-power operation. Available with 4, 5, 6, 8, 10 or 12 cylinders, ranging from 450 to 2500 kw per unit, with automatic or manual controls. **For full details or custom specifications, write today to: S. K. Howard; Director of Marketing; Fairbanks, Morse & Co.; Beloit Division; Beloit, Wisconsin.**

FAIRBANKS MORSE
A MAJOR INDUSTRIAL COMPONENT OF
FAIRBANKS WHITNEY

For more data circle 553 on Post Card

Equipment News

1—Modular design boiler with capacity to 250,000 lb per hr

Completely self-encased, the VU 60, introduced by Combustion Engineering, Inc., is an all-welded, gas-tight, envelope of finned furnace and boiler tubes, available in capacities from 100,000 lb steam per hour at 250 to 1000 psig. Steam temperatures to 900 F are standard with built-in flat curve of steam temperature to boiler rating. Firing may be horizontal (front wall) or tangential (corners) of oil, gas or both. With modular design, custom designs can be assembled from the standard components.

2—Slipring motors with direct air cooling rotors

Hollow conductor rotors are used by English Electric to provide direct air cooling for high speed, large slipring

motors. Designed primarily for driving boiler feed pumps, these motors can be used for other high speed industrial drives needing speed variation and/or a low starting current. Design allows air to enter at both ends of conductors, made from rectangular section copper. This keeps end windings cool while increasing efficiency of motor by reducing to minimum cooling air required.

Reader Service Cards on pages 99-100 make it easy to get further information on any of these products. Just circle the item numbers of the products you want to know more about.

4 — Joint compound provides improved electrical properties

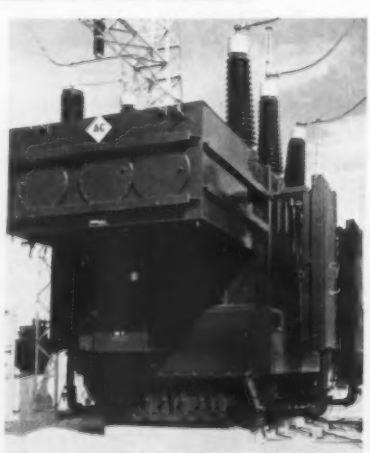
Alnox, a product of Rome Cable Div., Aluminum Co. of America, remains pliable enough for application at temperatures down to zero, but won't melt or run at 550 F. It contains minute conductive metallic particles. These hard and brittle particles are shattered under joint forming pressure and become embedded in the contact surfaces of the conductor. Effect of this is to produce intimate metal-to-metal contacts, which increase the joint's electrical efficiency. For aluminum-to-aluminum and aluminum-to-copper connections, Alnox prevents corrosion by excluding moisture. It can be used for bolted and compression connections.

5 — Horizontal opposed compressors install in limited space

Compressors in the WF Series of Joy Mfg. Co., in the 300- to 2000-hp range, handle most industrial air and gas applications. All have motors mounted directly on the compressor shaft to minimize alignment problems and simplify installation. For use in limited space, they have no extensive foundation requirements. WF Series Compressors are built on a 10- and a 12½-in. stroke frame. Bulletin A-74 covers it.

3—Load tap changing transformers cost less to buy, install

Major design advance in load tap changing transformers of Allis-Chalmers Mfg. Co. saves 20 per cent in size and weight, reduces losses 15 per cent and more. The new equipment is available for use on autotransformers 50,000 kva and larger. Manufacturer points out that formerly load tap changing autotransformers required a series transformer to introduce voltage regulation into the line, the tap changing mechanism being located in a tertiary winding. This meant an additional core and coil assembly inside the transformer rating and an even greater proportion of overall size. With the new unit, the tap changer regulates directly in the line-end of the winding —no series transformer needed.



6—Watertight switch for underground distribution system

For use where positive and safe operation is needed without frequent adjustment and inspection, the M-35, a three-pole, 5 kv, 300 amp oil switch of Allis-Chalmers Mfg. Co. is claimed to withstand momentary and short time currents to 25,000 amp. It has porcelain insulators, copper brushes, stud and contact blocks. May be wall mounted or in manholes and subways.

7 — "Set and forget" closed circuit television

The Hawk 401, a weatherproof, dustproof television system, can be installed in exposed, hot or cold, inaccessible locations and will perform without care

or attention, according to Diamond Electronics. The 401 operates successfully over the widest possible range of light, company says, with ample clarity provided for surveillance requirements. It operates from an ordinary 110-v a-c outlet, weighs 23 lb, is 19½ in. long. Any standard 16mm mount lens may be used with it.

8 — Meter measures current easily in tight spots

Difficulties in measuring current, voltage etc. in inaccessible areas are claimed virtually eliminated, with the lightweight, one-hand-operable "Pistolmeter" of Federal Pacific Electric Co. Revolving jaws permit insertion into cramped places. A locking device enables reading after removing meter from the tested conductor. The color-coded scale has four current ratings, 0 to 15, 60, 200 and 600 amp, two voltage ranges, 0 to 150, 600 v, and two ohmmeter ranges, 0 to 500, 5000 ohm. The meter is trigger-operated, furnished with test leads, battery charger and protective holster.

9 — Phase protection relay with application versatility

Outstanding feature of the Type IRV Relay is an instantaneous overcurrent unit having no transient response, operating with an internally mounted saturating transformer which limits the energy to the instantaneous-overcurrent unit at high fault currents and reduces the burden on the current

ONE OF A SERIES OF CHATS ABOUT CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

SO YOU THINK YOU'VE GOT TEMPERATURE CONTROL PROBLEMS

When plant men get together and talk about their temperature control problems, strong men may weep. It's so darned basic—that narrow range of degrees which must be maintained—so closely allied to profit and loss. Let us tell you about one situation that may even top yours, and may clue you in on a good solution. It concerns wine, of all things.

Take those basic temperatures. Wine must be pasteurized at 140°F. Those are the facts of life in the world of wine. They might not seem too difficult to live with unless you are concerned with heat. Then you probably know how tough things can get when you have a rendezvous with a thermometer.

Take New York's Monarch Wine Company, producers of Manischewitz Wines. Their Problem: how to maintain the 140° temperature in the heat exchangers despite wide variations in the rate of wine flow. These variations, between 5 to 60 gallons per minute, result from slowdowns and recoveries in the bottling process. Problem: entire system must be capable of complete shutdown when necessary. Problem: wine temperatures must be raised to 140° as rapidly as possible, sometimes an immediate jump of 100°.

Attracted perhaps by aspects of the situation that had little to do with pure science, Sarco engineers applied the collective experience of Sarco technology to the solution of this serious problem. The result for Monarch: the *degree of control* the process demanded—achieved through the excellent use of Sarco Temperature-Pressure Regulators, Float Thermostatic Steam Traps Thermo-Dynamic Steam Traps, and Pipeline Strainers.

Sarco engineers, ever resourceful, divided each of the two large Cherry-Burrell plate-type heat exchanger units into two separate

sections with a blank baffle plate, each with a separate Sarco control. Thermal sensing bulbs were installed in wine discharge and throttling controls hooked into steam supply. As demand fluctuates, one or both regulators function to maintain the 140° temperature. In higher demand, both regulators are operative; as demand drops and flow decreases, only one regulator supplies steam. Pasteur himself would have been elated.

Each of six smaller capacity shell-and-tube heat exchangers required only one regulator, with the sensing bulb inserted into the outlet side of the wine filled shell, and the regulator throttling steam supply to the tube section. Thus, by controlling flow of steam to the exchangers on the basis of pressure and temperature, the Sarco regulators were able to maintain the temperature of the wine at precisely 140° regardless of fluctuations in demand or supply rate. Whew! A lot of engineering went into those two sentences.

From here on it's downhill. To secure complete cut off of the steam supply during scheduled shut-downs of the bottling run, solenoid valves were provided to supplement normal modulating action of the controls. To discharge widely varying loads of condensate continuously and remove immediately all air and incondensible gases, Sarco Float Thermostatic Steam Traps were installed on all condensate outlets. On the drips before each control valve a Sarco Thermo-Dynamic Steam Trap was installed to insure delivery of dry steam. Sarco Pipeline Strainers were installed before all steam traps and valves to protect them against damage by any foreign bodies. And thus ends a classic story of the grape.

Still, this story has been condensed far too much, really, and we feel you've been cheated out of the story's more delicious details. You needn't be, however. We've printed the facts in detail for posterity and you in Sarco Case History 185, complete with drawings that practically make it a do-it-yourself kit. If you would like a copy, we will be flattered to receive your request, and dispatch it with dispatch.

WE'RE ALWAYS IN... AND THE WELCOME MAT'S OUT

We always take it for granted that if you are going to be in the vicinity of our plant you'll phone or drop us a line so we can invite you to visit us. You'll find that our factory in Bethlehem, Pennsylvania, is on many well-travelled routes, and that our steam laboratory has much to offer in interest and helpfulness. Forgive us for being immodest, but the lab is the most up-to-date of its kind in the country.

When you visit us, don't allow yourself to get sidetracked by the drill presses and automatic lathes. We're proud of this equipment but you've probably seen metal mutilated before, and it's our steam laboratory that's unique. We promise you a good show, and if you have any problems, bring them along. We'll solve them while you wait.

ANYONE FOR KEY CHAINS?

Need a key chain? A tiny replica of a Sarco Thermo-Dynamic Steam Trap, Type TD-50 is attached but you can always remove it if you find it too commercial. There are many things you could use these chains for. Fishing sinkers? Lengthening a light cord? Even holding keys? Anyway, if your Sarco representative is out, write in.

Pardon our monopolizing the conversation in this series of paid communiques, but we're trying our best to interest you in certain subjects that concern us both—to the point where you'll communicate.

6355

SARCO

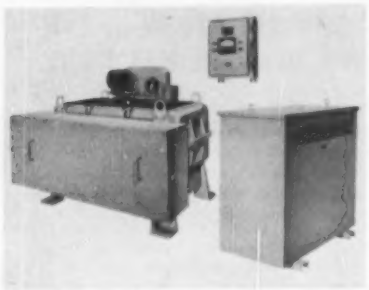
SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.
STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

For more data circle 554 on Post Card

transformers. Other features announced by manufacturer, Westinghouse Electric Corp., are a directional unit that torque controls both time-overcurrent unit and instantaneous-overcurrent unit. Versatility of application is provided by the wide range of time-curve characteristics and variety of time-dial settings available.

10—Regulator for constant output, zero waveform distortion

The EMHC Series Stabiline Automatic Voltage Regulator, for heavy-duty 50/60 c, three-phase application introduced by The Superior Electric Co. has standard assembly ratings of 460 v nominal



output voltage, 380-520 v input range, 440-480 v adjustable output range. Available in 240 and 480 kva units, special units with higher capacities and other input ranges may be ordered. Features announced include efficiency to 99 per cent, 0.28 sec per volt correction rate, insensitivity to magnitude and power factor of load, no effect on system power factor and full circuit protection. Stabiline Bulletin S461-EMHC gives details.

11—Lane markers are low in cost, easy to store and carry

These high visibility markers of Stokes Molded Products are composed of interchangeable yellow tubes set in separate 10-in. square black molded bases. The tubes come in heights from 12 to 72 in. The units have good impact resistance and the molded-in colors cannot wear or flake off. These markers occupy less space than conventional cones, and will accommodate presently-used standard accessory flags, warning signs or flashing lights.

12—Utility unit is an aerial lift, pole digger, winch, pole setter

An optional earth borer that converts the HV Elbow into an all-purpose utility tool is offered by Holan Corp. An attachment near the end of the lower

boom accommodates the earth borer, enabling the unit to bore holes as far as 13½ ft from truck. Because the Elbow rotates 360 deg continuously in either direction, the digger and derrick can be operated behind and on either side of the truck. The Elbow—which lifts workmen to 50- and 55-ft working heights—features two sets of A frame diagonal outrigger jacks and an aircraft-type cable control system provides control of the Elbow for spotting men and equipment.

13—Inhibited descalant remains stable at high temperatures

Oakite 132, an inhibited scale and oxide remover, is announced by Oakite Products, Inc. When used in closed systems, solutions of the compound can be heated to 180 F for faster descaling and derusting. The compound has greater tolerance for sulfur dioxide and ferric ions, reduces copper ion deposits, has a degree of inhibition in the vapor stage and good rinsability with hot or cold water.

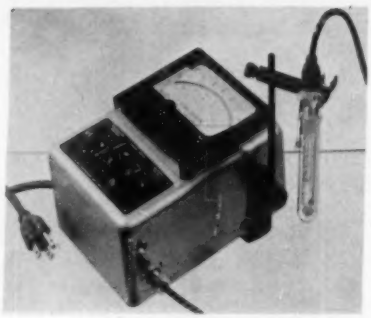
14 — Sealed oil cutouts are lighter, more compact

Introduction of General Electric Co.'s 15-kv sealed oil cutout completes their 5.2 to 15 kv vented and sealed line of oil cutouts for load break operation and overcurrent protection on distribution systems. Units are said to be 29 per

cent smaller, 41 per cent lighter than other types. The sealed units are designed for use only in hazardous atmospheres or where there is a possibility of submersion, in such applications as vaults, manholes and underground network systems. The new units can be used for load-switching on transformers, in metal-enclosed assemblies or rack-mounted installations.

15—Portable pH meter has mv scale, combination electrode

Electrion II, a product of The Meaker Co., is a line-operated portable pH meter with ±500 mv scale and a full-range, shock-resistant combination



electrode. Features announced include high stability and precise, reproducible readings (standardization once-a-week or less); constant-reading meter; stabilized amplifier; fast-response tubes; and 115-v line operation. Accurate measurements from 0 to 14 pH at 15 to 70 C are reported.

16—Pneumatic impact wrenches have high run down speed

Series 400 Pneumatically Operated Impact Wrenches, introduced by Airetool Mfg. Co., have a ¼-in. bolt with a ¼-in. female hex quick-change chuck, ⅜- and ½-in. drive squares. All mod-

els have a ¼-in. pipe tap, with pistol grip or straight type handles. Operating on low air consumption, wrenches have a high run down speed, and are reversible, with full power.

17—Ball valves with tight shutoff fire-seal seats

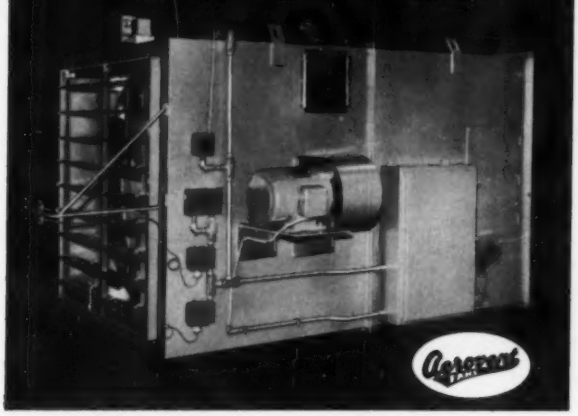
Fire-Seal seats are incorporated into Hills-McCanna Co.'s ball valves to assure tight shutoff of flammable or dangerous fluids in event of fire which

two of a kind...

for all in-plant requirements

direct-connected belt-driven

Gas-fired air make-up units



Let the breezes blow! You can maintain uniform temperatures and derive maximum efficiency from heating and ventilating systems *this* winter with Aerovent Gas-Fired Air Make-Up Units. And, you will be ready for next summer's heat, too, since each unit also serves as a filtered air supply unit. Why not investigate, today?

Standard models for all structures and all requirements in sizes 27" through 60" for capacities to 50,000 CFM and BTU/hr ratings to 4,875,000. Other units to specifications for capacities to 100,000 CFM and heat releases to 10,000,000 BTU/hr. Write for details and application data included with new Bulletin 860.

Air deliveries of all Aerovent equipment are tested and rated in accordance with established and accepted codes and each unit is guaranteed by the manufacturer to deliver its rated performance. CERTIFIED PERFORMANCE

Aerovent FAN COMPANY, INC.

ASH and BRUSH STS. PIQUA, OHIO

For more data circle 555 on Post Card

TOP
New Warfleigh Pumping Station on White River in Indianapolis, pumps water from the storm sewers over the levee at the rate of 246,000 gallons a minute.

BOTTOM
These five IDEAL motors totaling 2,800 H.P. supply the power at the Warfleigh Pumping Station.

The firm of MOORE & HEGER was the Consulting Engineer on this project.

control a flood...or water a city with IDEAL MOTORS

Five IDEAL Motors, 2—400 H.P., 2—600 H.P. and 1—800 H.P., supply the power to control flood water at the Indianapolis Warfleigh Pumping Station. These slow speed Vertical Solid Shaft Synchronous motors power pumps that have a capacity of 246,000 gallons of water per minute, (enough water to fill a 35' x 75' x 12½' deep swimming pool in one minute).

Whether it is power to control a flood or supply water for a large municipality or commercial use . . . whether 10 or 10,000 H.P. is needed, Ideal Electric can furnish the exact motor for any pumping requirement.

IDEAL'S more than 50 years' experience in engineering and manufacturing electric motors, generators and controls results in IDEAL PERFORMANCE on any job.

Write for Ideal's newest booklet, "Ideal Powers Pumps For The Motor City."

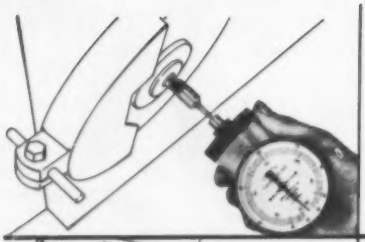
The IDEAL ELECTRIC AND MANUFACTURING COMPANY

610 East First Street Mansfield 2, Ohio

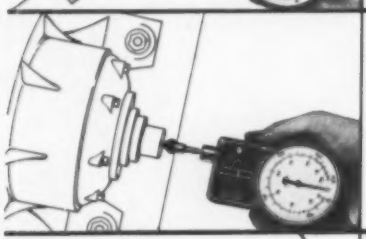
MOTORS, GENERATORS AND CONTROLS TO 10,000 H.P.

For more data circle 556 on Post Card

Check Speeds with a
BIDDLE Tachometer
and be sure!

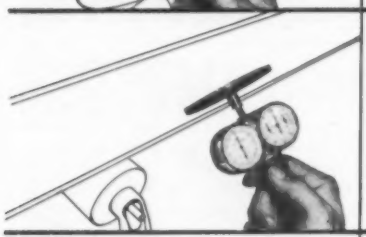


a **JAGABI® Centrifugal TACHOMETER** reads instantaneous speeds or variations in speeds up to 48,000 RPM. Single or multiple ranges.

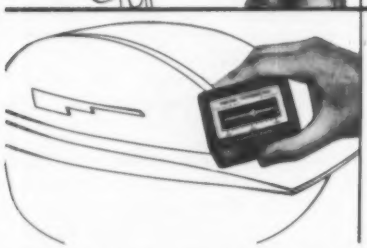


DR. HORN TACHOMETER is a centrifugal type instrument with 6 ranges for checking speeds from 25 to 30,000 RPM.

JAGABI® Chronometric SPEED INDICATOR measures *average* speeds. Available in ranges from 100 to 100,000 RPM.



the **JAGABI® TACHOSCOPE**—a stop watch and revolution counter in one—gives average FPM and RPM up to 20,000.



FRAHM® Resonant Reed TACHOMETER checks speeds *at a touch*. Requires no contact with moving parts—reads directly in RPM.

There's a Biddle Hand Tachometer precision-engineered for every speed measuring need . . . each complete with *all* accessories and carrying case, as required . . . and all backed by Biddle Reliable Repair Service. To help you select the Biddle instrument best for you, write for BULLETIN 35PE.

B136

BIDDLE INSTRUMENTS

JAMES G. BIDDLE CO.

Electrical & Speed Measuring Instruments

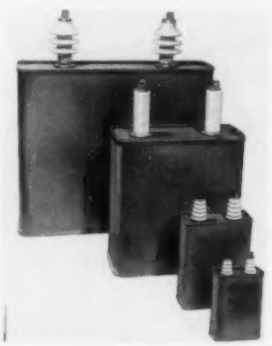
1316 ARCH STREET • PHILADELPHIA 7, PA.

For more data circle 557 on Post Card

might elevate temperatures beyond limits of standard non-metallic seating materials. Construction consists of primary seat of metal-encaged reinforced Teflon with secondary metallic seating surface. If Teflon is destroyed by excessive heat, shutoff of flow is assured by metal-to-metal contact between ball and secondary seat. Valves are stocked with screwed ends, in 1- through 3-in. sizes and with flanged ends in 1- through 8-in. sizes, as well as bar stock valves, ¼- through 2-in. screwed end sizes.

18—Small, lightweight capacitors for power filters

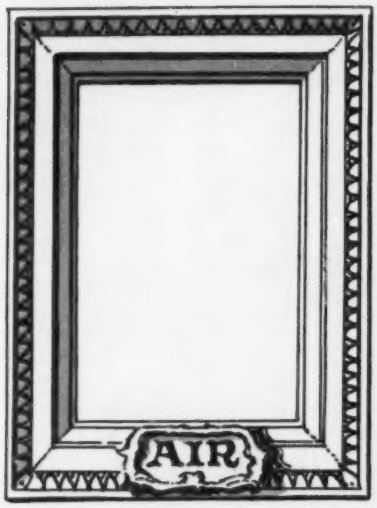
These high voltage d-c Mylar capacitors for voltage doubler circuits, receivers and transmitters, energy storage, audio coupling are announced by



Corson Electric Mfg. Co. The hermetically sealed units are designed for 10,000-hr life at 65 C, and are suitable for use from —60 to 105 C. A triple dielectric construction is employed to enable the capacitor to withstand high voltage stress. This consists of a polyester film and thin layers of high density kraft paper. The paper absorbs a chemically pure, high viscosity polybutene oil, adding the third dielectric. The terne or hot-tinned container coating resists humidity and salt environments. Fifteen ranges are available from 1000 v to 50 kv d-c. Catalog 104 gives data.

19—Metal tube flow meters for hazardous materials

Metal-tube Varea-meters introduced by Wallace & Tiernan Inc. are variable area flow meters for use at temperatures and pressures beyond range of glass-tube meters. They come with 150 and 300 lb. flanges and are supplied in materials to handle wide range of chemicals. Tube diameters range from ½ to 3 in., water capacities from 1 to 400 gpm and air capacities from 4.2 to 1680 scfm. Meters feature interchangeable floats. Each tube will accept any one of a family of



HOW MUCH AIR
is in the picture?

Too much?
Too little?
Just enough?

It really doesn't matter UNLESS you have a boiler, kiln or process furnace you'd like to operate safely and efficiently.

A Reliance-Kent Oxygen Analyzer in your combustion air picture means an end to costly guesswork about combustion efficiency and safety.

O_2 ANALYZER

- Paramagnetic operating principle
- Automatic—and adaptable for control
- For continuous, accurate measurement

O_2 RECORDER

- Null-balance potentiometer type
- Strip Chart *or*
- Circular chart

Ask for Bulietin No. 1002

RELIANCE INSTRUMENT
Division of ELECTRO-MECH Corp.

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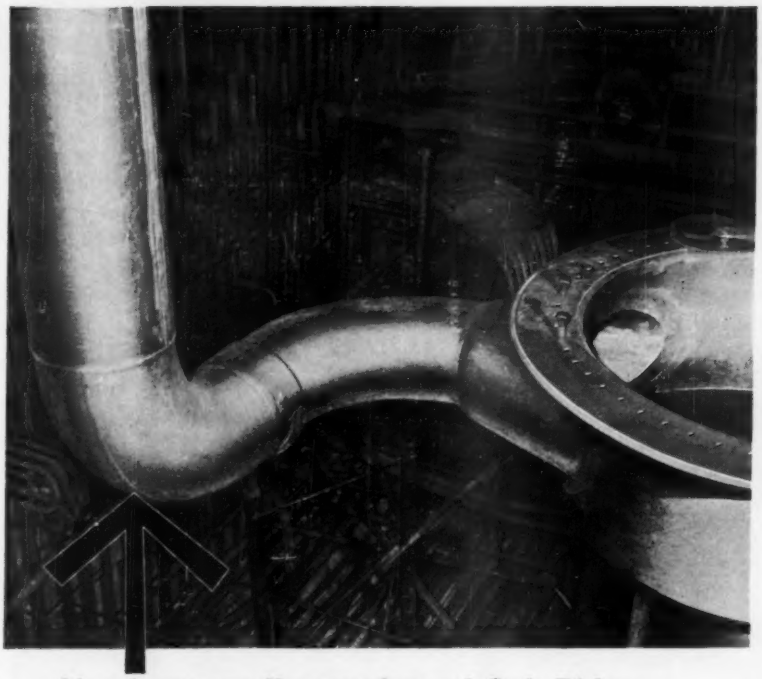
from ALCOA
good designs made better with aluminum



Aluminum cooling system at Oak Ridge includes Tube-Turn fittings

At Oak Ridge National Laboratory, a cooling system utilizing aluminum forces more than 12,000 gal of water per minute through the research reactor. Welding fittings up to 24 in., thought to be the world's largest of aluminum, were made with Alcoa® Aluminum by Tube Turns Division of Chemetron Corporation, Louisville, Ky. Aluminum was selected to maintain purity of the demineralized water. Other advantages: aluminum's low cost, corrosion resistance and superior heat-transfer ability. To take advantage of Alcoa's 35 years of heat exchanger experience, please send the coupon.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Aluminum Company of America, 828-X Alcoa Building, Pittsburgh 19, Pa.

Please send me the following literature:

☐ 34-10197 *Aluminum Pipe and Fittings*
☐ 68-10460 *Process Industries Applications of Alcoa Aluminum*
☐ 34-11566 *Alcoa Aluminum Heat Exchangers and Condensers*

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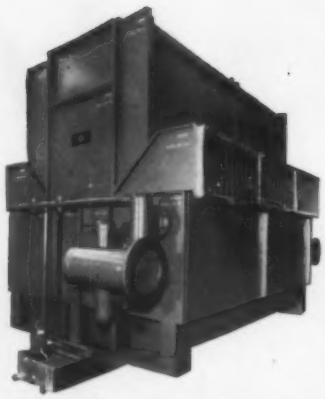
Company_____

Address_____

City_____ Zone_____ State_____

For more data circle 559 on Post Card

You Get EXTRA SAVINGS From This Method of Compressed Air After Cooling



Cooling water savings and power savings quickly repay the cost of the Niagara Aero® (air-cooled) After cooler for compressed air or compressed gases. In addition its long life and the labor-saving simplicity of its maintenance give you an extra profit in comparison with water-cooled surface contact methods.

With the Niagara After Cooler the heat of compression is removed and dispersed into the atmosphere by the evaporation of a very small amount of water. The compressed air temperature is always brought below that of the atmosphere surrounding your air lines, so that no further condensation can take place.

Large users of compressed air for plant services or processes choose Niagara Aero After Coolers for their dependable durability. They have been making good records of service for over 25 years.

Write for Bulletin 130.

NIAGARA BLOWER COMPANY

Dept. E-10, 405 Lexington Ave., New York 17, N. Y.

Niagara District Engineers in Principal Cities of U. S. and Canada

For more data circle 560 on Post Card

"Your pumps perform well considering the severe service"
—a West Virginia power company.

Nagle horizontal shaft and vertical shaft centrifugal pumps have won the praise of numerous utilities, institutions, mills and municipalities—those which operate boilers or incinerators for heat, power, water or wastes disposal. Nagle pumps have established something of a record for handling ashes, slurries and drainage. Long term maintenance costs are very low. Both the materials used for construction and the design contribute to the longevity of these "uncomplaining" pumps.

Tough jobs call for Nagle PUMPS FOR ABUSIVE APPLICATIONS EXCLUSIVELY

Two Nagle 8" type "TR" pumps are shown handling crushed boiler ash and water to a dewatering bin for a West Virginia power company, which is certainly a *severe service*, but the Nagle pumps are performing admirably—have proved a sound investment. Get more complete facts—send for Nagle Pump Selector. Nagle Pumps, Inc., 1229 Center Ave., Chicago Heights, Ill.

For more data circle 561 on Post Card

floats, each float having a capacity about 20 per cent greater than next smaller size.

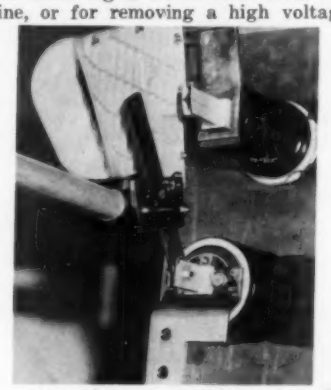
20—Power boiler tube cleaner works automatically

Introduced by Power Tube, Inc., Slugger reportedly cuts tube cleaning time in half, reducing heat loss by up to 30 per cent and cleaning tubes more

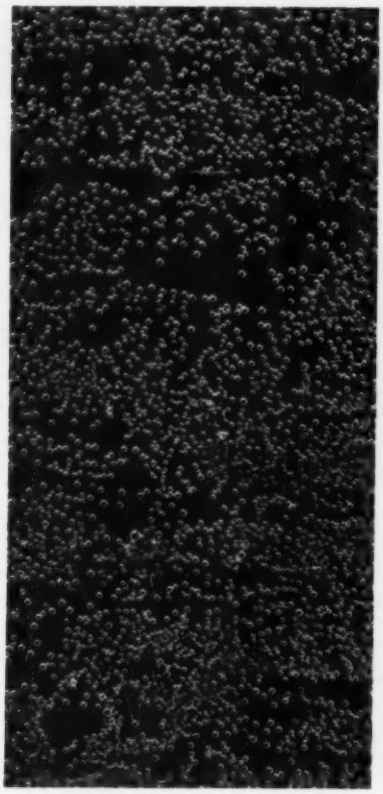
efficiently than by hand. It cleans soot and scale from fire tube boilers by means of an electrically operated punching brush that feeds into any boiler tube. One machine can service any number of boilers—even within 3 ft of a wall. No compounds are required and no shutdown to cool tubes for punching.

21 — Air and oil switches for load break or sectionalizing

Announced by Westinghouse Electric Corp. for integral assembly with pad mounted distribution transformers, either of these switches can be used for removing a transformer from the line, or for removing a high voltage



feeder from service. The air switch normally passes load current through main contacts and disconnect blade. In parallel with these contacts, however, is a second set of contacts and a quick-break blade in a Delrin plastic arc chute. To break the load, you pull the disconnect blade open. As it opens, load current is diverted through the quick-break blade. After the disconnect blade is open enough to prevent restrike, the quick-break blade snaps open and the arc is extinguished in the chute. The oil switch is assembled as



DEOXY-SOL REDUCES OXIDES

in boiler feed water yet adds no solids

– and that may be a good reason to select DEOXY-SOL for treatment of your boiler water. But it provides other advantages also.

DEOXY-SOL is a high efficiency oxygen scavenger, since it is a solution of hydrazine. And it raises the pH, supplementing any amine treatment.

Stocks in Newark, N. J., Chicago, Ill., Los Angeles, Calif.

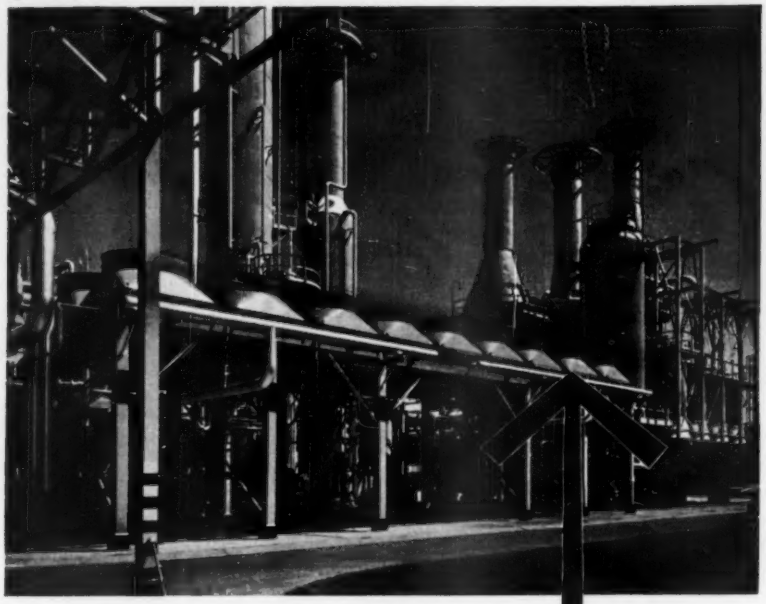
Write for informative Bulletin BW.

Fairmount
CHEMICAL CO., INC.
136 Liberty Street New York 6, N. Y.

For more data circle 562 on Post Card

from ALCOA

good designs made better with aluminum



improves process cooling rate, resists corrosion at Southwestern Oil & Refining Company's Big Texas Refinery

Aluminum's superior ability to transfer heat finds practical employment in this Solo-Aire cooling installation, made with ALCOA® Aluminum by Hudson Engineering Corporation, Houston, Texas. Light, bright aluminum has other advantages here: notable corrosion resistance and remarkable low-temperature properties. Installed at Corpus Christi, Solo-Aire is clear evidence of another good design made better with aluminum. Perhaps ALCOA can help improve your good designs. For more information, please mail the coupon.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

Aluminum Company of America, 828-K Alcoa Building, Pittsburgh 19, Pa.

Please send me the following literature covering Alcoa Aluminum for tubular products and other uses in the process industries:

- ☐ 68-10460 Process Industries Applications of Alcoa Aluminum
- ☐ 88-11453 Solving Refinery Corrosion Problems with Aluminum
- ☐ 02-19051 Alcoa Aluminum Handbook
- ☐ 42-20849 Resistance of Aluminum Alloys to Weathering and Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres
- ☐ 34-20437 Aluminum Alloy Heat Exchangers in the Process Industries

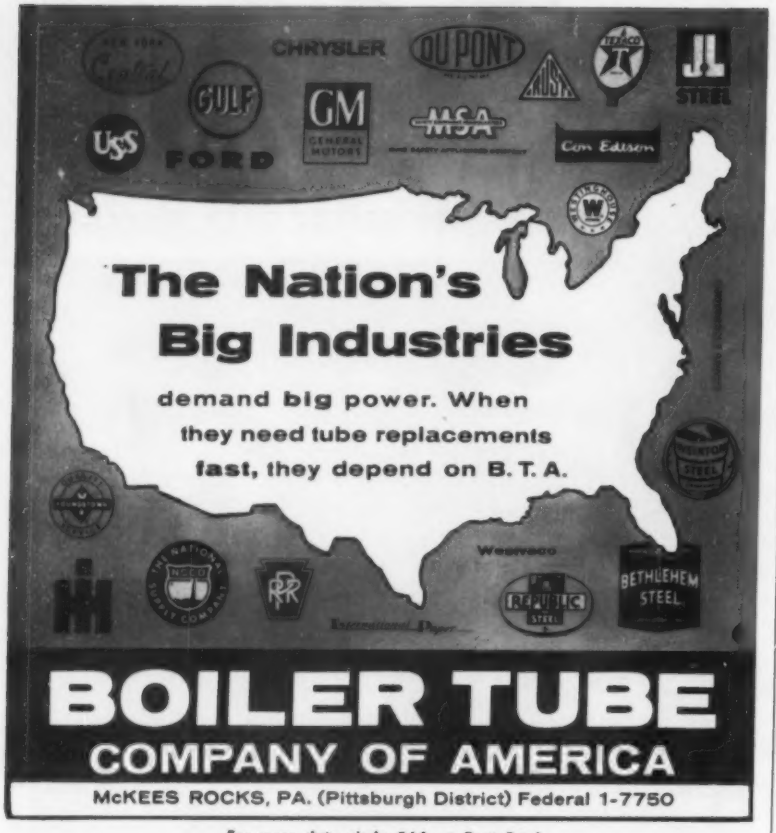
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

For more data circle 563 on Post Card

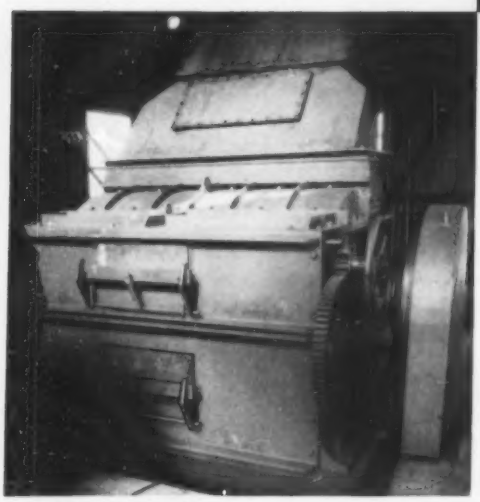


BOILER TUBE
COMPANY OF AMERICA
McKEES ROCKS, PA. (Pittsburgh District) Federal 1-7750

For more data circle 564 on Post Card

CRUSHING FACTS
from *American* PULVERIZER CO.

USER REPORTS



"We've reduced 2,521,000 tons of 2" N & S coal to a ¾" product. Rings and screens have been renewed only once. Replacement parts have cost $0.0016 per ton, including standby parts."

When you figure Costs, the best results come from American Rolling Ring Crushers.

American PULVERIZER COMPANY
ORIGINATORS AND MANUFACTURERS OF RING CRUSHERS AND PULVERIZERS
1431 MACKLIND AVE. ST. LOUIS 10, MISSOURI

For more data circle 565 on Post Card

a high-voltage porcelain insulator that serves as one entrance bushing as well as switch support. Both switches can be used on systems up to 14.4 kv, have a basic impulse level of 95 kv. Continuous current rating is 200 amp, momentary 10,000 amp asymetrical.

22—Conversion calculator gives Metric and English factors

Instant conversion calculations are provided with Kelm Mfg. Co.'s Metric-English Conversion Calculator. Gives

decimal equivalents from 0.01 mm to 100 mm, Centigrade-Fahrenheit factors from —459.4 F to 3000 C, as well as decimal and metric equivalents of parts of an inch and a large number of simple formula conversions. Costs less than $2 in quantities.

23—Electric transmitters with 5 d-c signal choices

The solid state electric rotameter transmitter, by Schutte & Koerting Co., with its choice of output signals, meets the requirements of most electric receivers and computers. Operation is on induction principle. The transmitter is contained in a metal housing coupled to company's Safeguard or metal tube Rotameters. This makes it capable of transmitting flow rates to 200 gpm, in up to 3-in. pipes, to 600 psig.

24 — Welding and cutting kit for heavy duty jobs

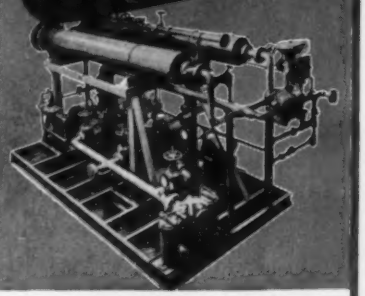
Included in the 6325-C Welding and Cutting Outfit by The Harris Calorific Co. is the 63-F heavy-duty welding torch which takes up to Size 22 tip (No. 24 drill orifice). It features high temperature silicone O ring seals that permit fast, easy change of tip assemblies. Head-mix-type cutting attachment will cut up to 6 in. and features triangular tube construction. Its preheat valve also serves as oxygen shutoff. Industrial size Model 25 regulators can weld heavy jobs. Included in

save on installation and maintenance

with

EAGAN

FUEL OIL PUMP and HEATER SETS



Use an Eagan "pre-packaged" fuel oil pump and heater set for the preparation of heavy oil for combustion. You save time and money because units are completely assembled, ready for immediate installation. Only connections to oil and steam supply, burner, by-pass and relief lines have to be made and you avoid the combustion difficulties so often caused by field assembled combinations.

Here are additional benefits Eagan gives you:

- **Generous reserve capacity, at least 50% over peak burner demand, allows for eventual wear and future demand increases.**
- **Maintenance is easy and at a minimum. Parts requiring service are easily accessible.**
- **"Honest", solid construction, excellent engineering assure long life, trouble-free operation.**
- **Compact units save space.**

EAGAN fuel oil pump and heater sets heat to 300° F, pump to 400 psi and have capacities to 3000 gph. Single or duplex units are available for steam or electric drive. Duplex "electro-steam" sets provide for electrical failure by incorporating one steam pump and one electric motor driven pump. Other EAGAN sets can be made to your special requirements.

Write, wire or call for further information or let us bid on your job.

WALTER H. EAGAN CO., INC.

2337 Wallace Street, Phila. 30, Penna.

CEnter 6-2300

Mfrs. of condensate, boiler feed, turbine, centrifugal and proportioning pumps and fuel oil pump and heater sets.

Pump Specialists Since 1920

For more data circle 566 on Post Card

from ALCOA

good designs made better with aluminum

Bright, maintenance-free aluminum ductwork covering throughout—specified by Stearns-Roger for new Ben French Station

Insulated gas ducts, air ducts, air heaters and fan housings were covered with Alcoa® Aluminum to achieve a modern, attractive appearance and a surface that never needs attention. It is aluminum covered ductwork throughout at the new Ben French Station—installed by Stearns-Roger Manufacturing Co., Denver, Colo., for Black Hills Power & Light Co., Rapid City, S.D. Aluminum sheet is easy to fabricate by conventional sheet metal methods, reports Stearns-Roger. Moreover, it pays off through the years with undimmed appearance and no maintenance. For more information, please send the coupon.

ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

Aluminum Company of America, 828-XX Alcoa Building, Pittsburgh 19, Pa.
Please send me the following literature:

☐ 17-11135 *To Produce More Kilowatts per Dollar . . . Alcoa Aluminum for Generating Stations*

Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

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BETTER TOOLS FOR BETTER WORK

Whatever your tube maintenance problem— look to WILSON

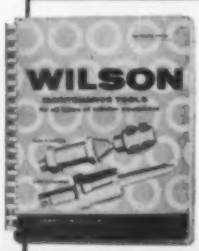
Wilson has hundreds more to meet every tube maintenance need. Send for comprehensive Catalog 77-88.

TORQ-AIR-MATIC AUTOMATIC EXPANDER DRIVES

TUBE CUTTER

TUBE EXPANDERS

TUBE PILOT



TUBE CLEANERS

RIGHT ANGLE GEAR DRIVE

TW-913

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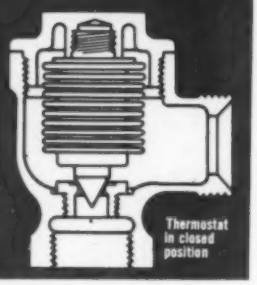
SAVE TIME AND MONEY ON STEAM TRAP MAINTENANCE!

Sterlco®

STEAM TRAPS

"FAIL-SAFE" VACUUM THERMOSTAT CLOSES TRAP IF DAMAGE OCCURS



1. Closed trap simplifies finding source of trouble . . . no steam is wasted . . . vacuum on vacuum system remains normal . . . pumps not endangered by steam in return lines.
2. Efficient operation regardless of pressure changes . . . vacuum thermostat compensates for pressure changes.
3. Small overall dimension assures easy replacement of your present traps.
4. "Fail-Safe" vacuum thermostat used in all Sterlco Radiator and F & T Traps.

For complete information on Sterlco Radiator and Float & Thermostatic Traps, write for Bulletin 102.

Condensation Pumps, Steam Traps, Heating Specialties

Leaders in temperature controls since 1915

Sterling inc.

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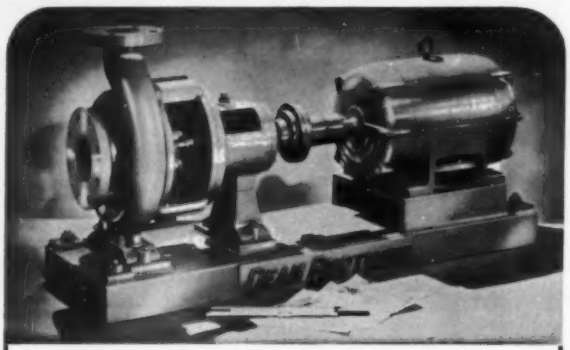

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✓ **Easy to Select**—28 sizes (14 horizontal, 14 vertical) available in 14 corrosion-resistant alloys, to fit your special pumping problem.

✓ **Economical to Buy**—Low first cost combined with easy servicing and maximum interchangeability of parts make pH pumps lowest cost in the long run.

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✓ **Economical to Operate**—Fully open impellers for slurries and clear liquids contribute to long, trouble-free service life with minimum down-time.

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DEAN BROTHERS PUMPS INC.

INDIANAPOLIS 7, INDIANA

The Best Is Our Standard

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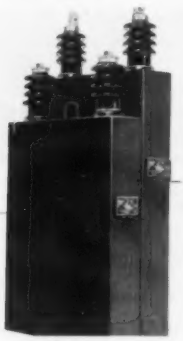
kit are extra welding tips, hose, lighter, goggles.

25—Smaller, lighter capacitor is easier to handle

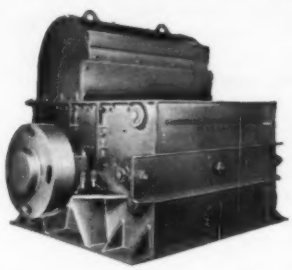
Line Material Industries' 50-kvar capacitor, rated 2.4 to 14.4 kv, with its weight reduction (from 91 to 70 lb) and size (tanks are 4-by-13½-by-20½ in.) is claimed lighter and smaller than others available, affording greater handling ease and use of lighter equipment. It features liquid circulation for



coolest internal operating temperature and improved pack design for increased safety. The 100-kvar unit also will be 30 per cent lighter in weight while retaining its 15⅝-in. mounting dimensions according to company.

This GRUENDLER CRUSHER handles

600 TONS OF COAL PER HOUR WITH EASE!



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Lower original cost
Lower maintenance
Top performance and production

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GRUENDLER CRUSHER & PULVERIZER CO.

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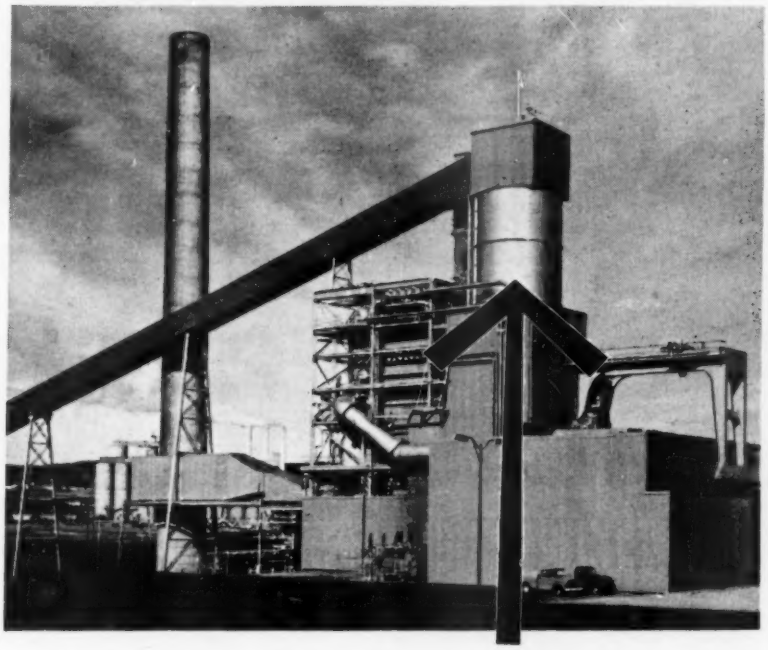
from ALCOA

good designs made better with aluminum



Stearns-Roger Manufacturing Co. designs Ben French Station with Alcoa Aluminum boiler lagging

The growing trend to outdoor boiler construction created a demand for a strong, lightweight, corrosion-resistant covering material. Aluminum is ideal for this application, as handsomely demonstrated by the new Ben French Station, Black Hills Power & Light Co., Rapid City, S.D. Boiler lagging of Alcoa® Aluminum was designed and installed by Stearns-Roger Manufacturing Co., Denver, Colo. In addition to improved function and appearance, aluminum saves money because painting is eliminated. For more information, please send the coupon.

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ALUMINUM COMPANY OF AMERICA

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Company_____

Address_____

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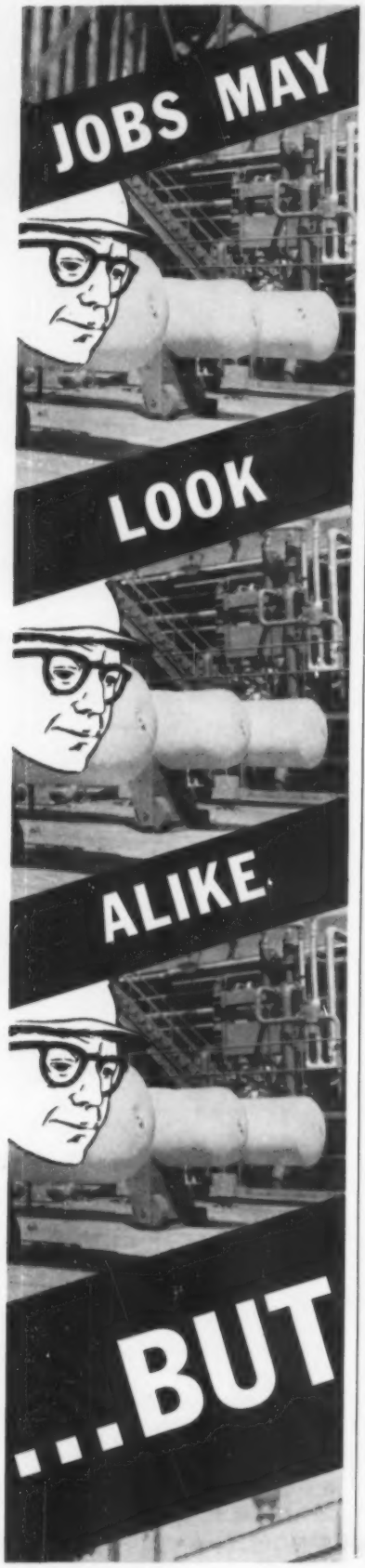

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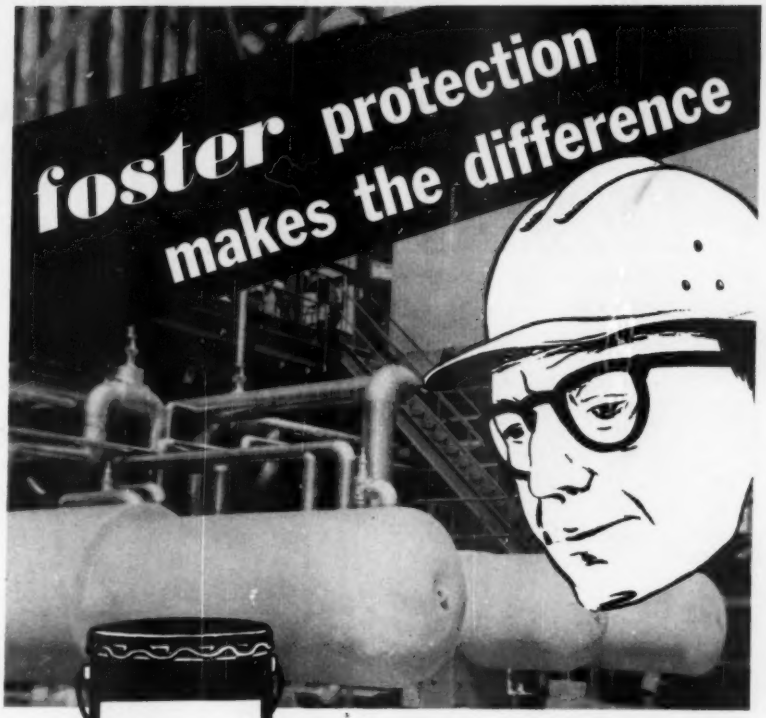

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only foster provides a Flame-Spread Index rating for every coating, adhesive, sealer and mastic we manufacture.

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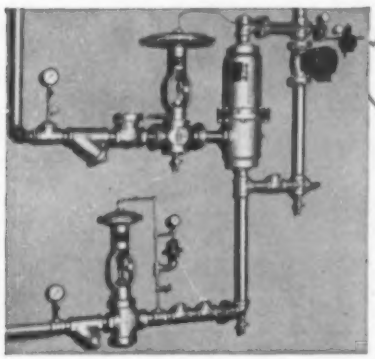
Accurate Temperatures . . .
Low Cost . . . Any Quantity from
500 to 50,000 Gallons Per Hour!



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for high or low pressure steam

Direct contact of steam and water in the Pick patented mixing chamber produces hot water at the desired temperature, and in the required quantity, *instantly!* There's no time lag . . . no steam wasted to maintain heat in stored water . . . steam used only as hot water is drawn. Water temperature maintained within 3° plus or minus. Volume adjustable from 5% to full rated capacity. Pick heaters require no floor space . . . usually installed on wall. Whatever your hot water needs are, Pick will do it faster, more accurately and at lower cost!

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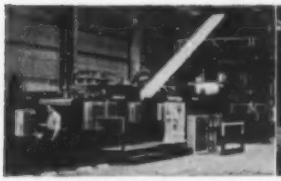

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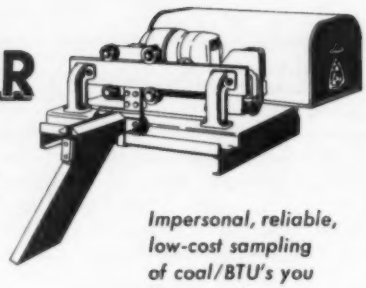

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Wet, dry and dust-tight units. Simple, reliable, automatic. Units with cutter travel to 10' and longer. New bottom-dump dry cutters (patent pending) for use where headroom is 10."

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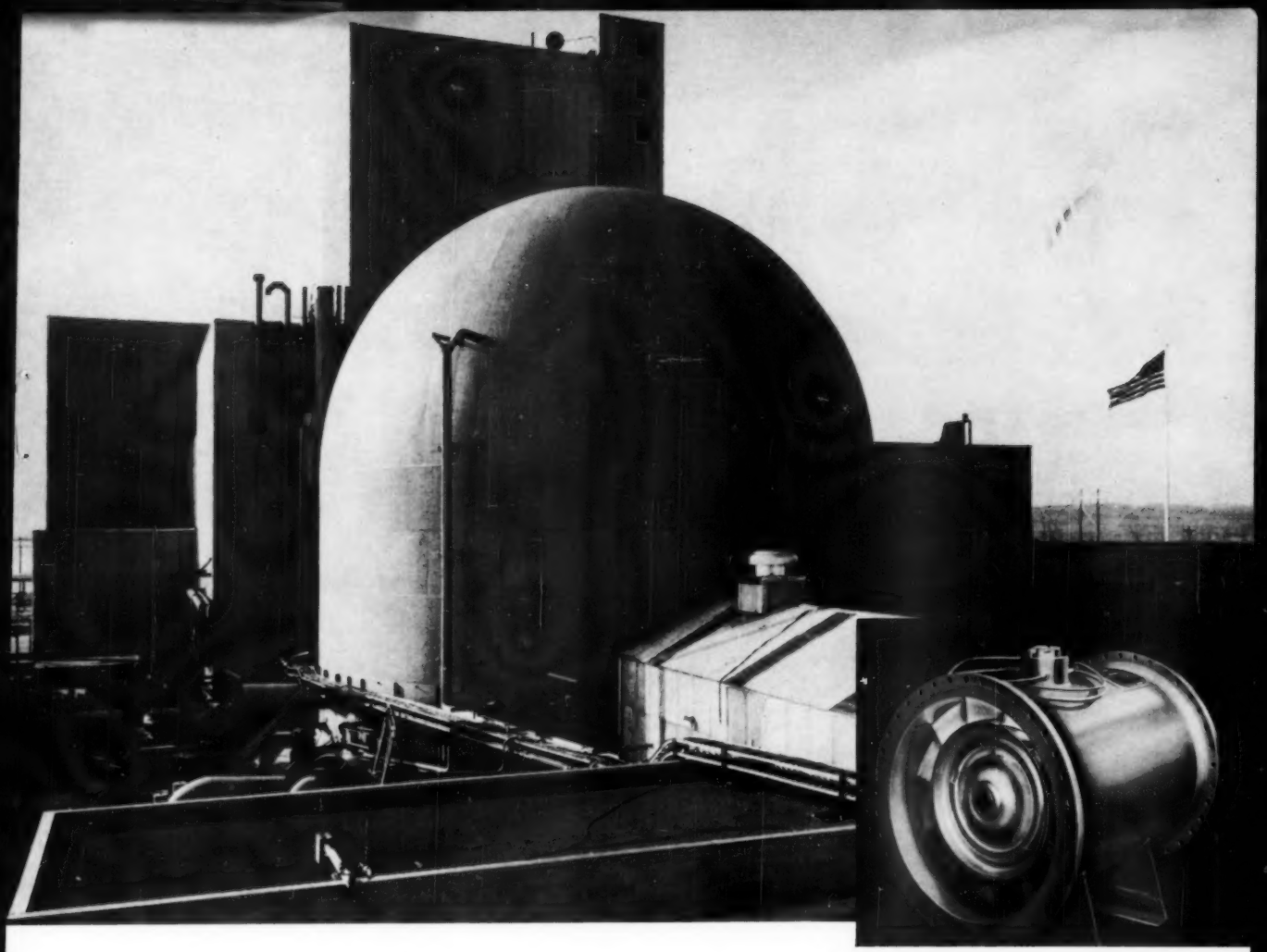


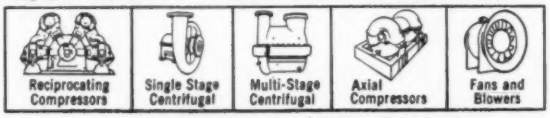
Two-stage JOY Axivane® Fans provide lower vessel ventilation at Enrico Fermi Atomic Power Plant

A special two-stage Joy Axivane Fan circulates the enclosed nitrogen atmosphere which provides lower vessel cooling for the world's largest fast neutron breeder reactor. Rated at 100,000 KW, the Enrico Fermi plant built by Power Reactor Development Company and The Detroit Edison Company will be among the largest atomic power plants in operation. In addition to handling the critical lower vessel cooling, Joy also provided the heavy duty fan for dilution of stack gas.

Joy Axivane Fans are ruggedly built to meet the most demanding service requirements. Power consumption is held to a minimum, because Joy Axivane Fans have adjustable pitch blades which can be set for any desired volume of air over a wide range. Drive motors can always be operated at their most efficient speed. To conserve space and cut installation costs, these fans can be mounted directly in the duct—motors are integral. V-Belt drive is available if desired.

Whenever you need heavy duty, economical ventilation fans, consult your Joy representative. For complete information on Joy fans, write for Bulletin 2549-56C.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

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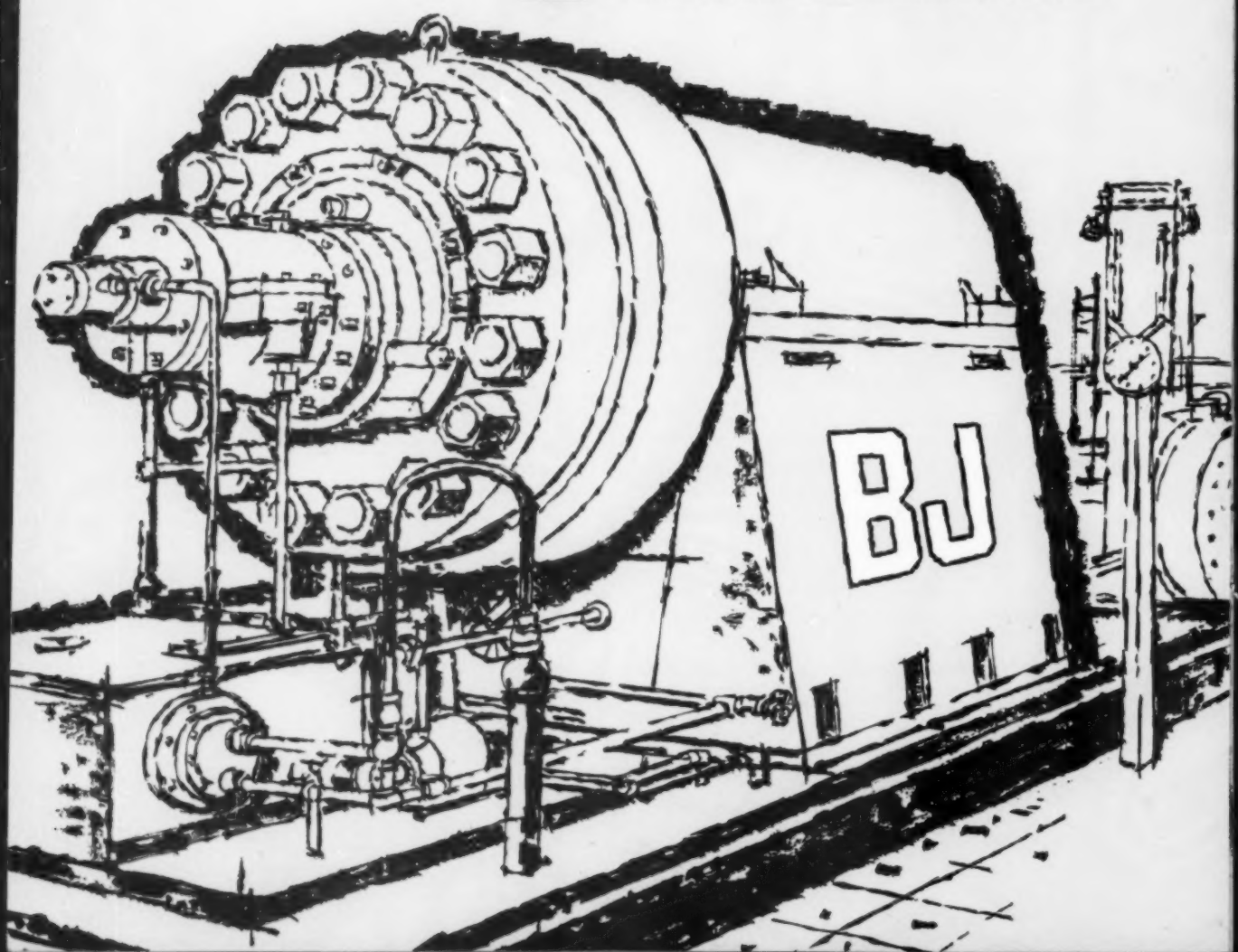
HP

When it comes to high horsepower pumps, BJ is the big leader!

Six recent Byron Jackson orders for a total of eleven boiler feed pumps all ranged from 7,000 to 12,000 horsepower and will deliver from 3,000 to 6,750 gallons per minute!

This dramatically points up the trend toward larger, higher horsepower pumps, both standard, steam turbine and direct turbine—generator driven. And since reliability is a must with these modern, big capacity boiler feed pumps, BJ's reputation for quality and proved performance really pays off!

BW

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